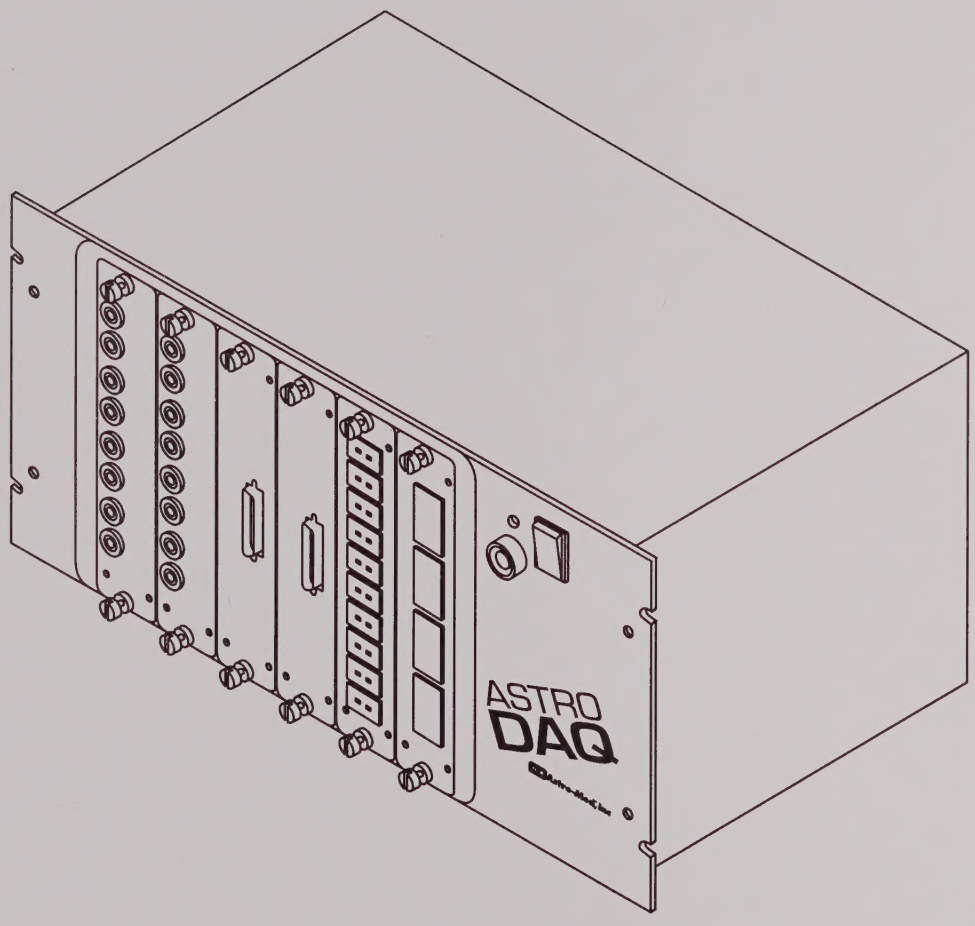

AstroDAQ® User Guide

Astro-Med,® Inc.

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AstroDAQ® User Guide

part number 22834-402

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second edition

AstroDAQ® firmware version 1.5
AstroLINK® 32 software version 5.6.1

Specifications are subject to change without notice.

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AstroDAQ Identification Data

Congratulations. Your Astro-Med purchase is an investment in the finest of state-of-the-art data acquisition technology. Record the serial number and software version number of your AstroDAQ below. If, for any reason, it should be necessary for you to contact Astro-Med regarding your purchase, please refer to the following:

serial number _____

software
version number _____

FCC Compliance Statement

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference; and (2) this device must accept any interference received, including interference that may cause undesired operation.

Shielded cables must be used with this unit to ensure compliance with the Class A FCC limits.

WARNING: Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Canadian Emissions Requirements

This digital apparatus does not exceed the Class A limits for radio noise emissions from digital apparatus set out in the Radio Interference Regulations of the Canadian Department of Communications.

Le present appareil numérique n'emet pas de bruits radioelectriques depassant les limites applicables aux appareils numériques de la class A prescrites dans le Règlement sur le brouillage radioelectrique edicte par le ministere des Communications du Canada.

Preface

The *AstroDAQ® System User Guide* is divided into four parts:

Part I (chapters 1 - 4)

provides an introduction to the system:
- overview of the system and its functions
- system specifications
- installing and starting AstroLINK® software
- system hardware overview

Part II (chapters 5 - 12)

describes each module used in the system:
- V08 / V08H differential voltage input module
- V04 isolated voltage input module
- BR4 bridge module
- TC10 thermocouple module
- EV16 event modules
- C08 counter module
- AM1 accessory module
- AC3 high voltage input module

Part III (chapters 13 - 19)

presents AstroLINK software:
- monitoring real-time waveforms
- capturing data
- managing, reviewing and archiving records
- using the Make Test and Sequencer windows
- identifying file types
- addressing network issues

Part IV (chapter 20)

provides maintenance procedures:
- maintaining your AstroDAQ

CONTENTS

TABLE OF CONTENTS

Contents

PART 1

1 SYSTEM OVERVIEW

System overview	1-1
Signal conditioner modules	1-2
Characteristics of the AstroDAQ enclosure	1-3
AstroGRAPH® chart recorder	1-3
Examples of AstroDAQ System configurations	1-4
Functions of the AstroDAQ System	1-6
Signal conditioning function	1-6
Signal monitoring function	1-6
Data sampling and primary storage	1-7
Data review	1-7
Conversion to popular formats	1-7

2 SYSTEM SPECIFICATIONS

Data capture	2-1
Signal conditioner modules	2-1
Trigger	2-2
AstroLINK software	2-2
Other features	2-2
Power	2-2
Physical	2-3
Environmental	2-3
Shock/vibration	2-3
AstroDAQ signal conditioner modules	2-4
AstroDAQ accessory module	2-5
Regulatory compliance	2-5

3 ASTROLINK SOFTWARE INSTALLATION

Connecting an AstroDAQ to a network	3-1
Starting the AstroLINK software	3-2
Adding an AstroDAQ	3-4
HELP functions	3-5
DDE capability	3-6
Module Control window	3-7
Scope tool	3-8

Contents

4 **ASTRODAQ MODULES: GENERAL INFORMATION**

About the waveform path in AstroDAQ Systems	4-1
Waveform broadcasting in the AstroDAQ System	4-2
Anti-alias filtering and channel bandwidth	4-2
Specifying user engineering units	4-3
Event processing	4-4
Analog outputs	4-5
Module specifications	4-6
Grounding	4-6
AstroDAQ enclosure grounding	4-7

PART II

5 **VO8 AND VO8H DIFFERENTIAL VOLTAGE INPUT MODULE**

VO8 and VO8H differential voltage input module	5-1
Channel specifications	5-2
VO8 input connector	5-3
DSP functions	5-3
Menu limits	5-3
VO8 parameter-adjustment window	5-4
VO8 technical notes	5-4
VO8 calibration	5-5
Differential voltage measurements	5-5
Current output transducers	5-7
Resistance temperature detector (RTD)	5-7
VO8 options	5-8

6 **VO4 ISOLATED VOLTAGE INPUT MODULE**

V04 isolated voltage input module	6-1
VO4 channel specifications	6-2
VO4 input connectors	6-2
DSP functions	6-3
VO4 menu limits	6-3
VO4 parameter-adjustment window	6-4
VO4 technical notes	6-4
VO4 calibration	6-5
Isolation amplifiers	6-5

7 BR4 BRIDGE MODULE

BR4 bridge module 7-1
BR4 input stage 7-2
Board-mounted switches 7-2
Channel specifications 7-3
Input connectors 7-4
DSP functions 7-5
Menu limits using the mV/V measurement type 7-5
Using the mV/V measurement type 7-5
Menu limits using the micro-strain (με) measurement type 7-5
BR4 parameter-adjustment window 7-6
BR4 technical notes 7-6
Basic DC bridge 7-8
Basic calibration 7-9
Secondary calibration feature 7-9
About the auto-balance (nulling) functions 7-11
Calibration resistors 7-12
Potentiometric transducers 7-12
Load cells 7-13
Pressure transducers 7-14
DC linear variable differential transducer (LVDT) 7-14
Strain gauges 7-15
Quarter-bridge circuits (general description) 7-17
Quarter-bridge circuits (BR4-specific) 7-18
Other bridge arrangements 7-19
Transducer wiring 7-19

8 TC10 THERMOCOUPLE INPUT MODULE

TC10 thermocouple input module 8-1
TC10 channel specifications 8-2
DSP functions 8-2
Menu limits 8-2
TC10 technical notes 8-3
Thermocouple measurements 8-3
Reference junctions 8-4
Linearizing TC measurements 8-4

Contents

9 EV16 EVENT MODULES

EV16 Binary Event Input Module	9-1
Board-mounted switches on the EV16	9-2
EV16 input specifications	9-3
EV16 input connector	9-3
Configuring an EV16 module	9-4
Monitoring switch closures	9-4
Changing input threshold	9-5
EV16A High Voltage Event Module	9-6
EV16A input specifications	9-7
EV16A input connector	9-7

10 CO8 COUNTER MODULE

CO8 input specifications	10-1
CO8 input stage	10-2
Counter mode	10-3
Rate meter mode	10-4
CO8 input connector	10-5
Board-mounted switches	10-6
Configuring CO8	10-6
Monitoring switch closures	10-6
Changing input threshold	10-6

11 AM1 ACCESSORY MODULE

AM1 accessory module	11-1
AM1 accessory module control menu	11-2
Triggering features of the AM1	11-3
Fixed channel OR stage	11-3
Variable channel AND/OR stage	11-4
Final OR stage	11-4
Variable channel trigger elements (PT1 - PT4)	11-5
Slew triggering	11-6
Monitor alarm mode	11-7
AM1 relay connector	11-8
AM1 signal connector	11-8
Input/Output (I/O) circuits	11-9
Digital inputs	11-9
Relays	11-10
Voltage level outputs	11-11
Clock output	11-11
Logic outputs	11-12
Onboard fusing	11-12
Technical notes	11-12

Slew trigger processing 11-12
Slew rates for sinusoids 11-13
Detecting drop-out 11-14

12 AC3 HIGH VOLTAGE INPUT MODULE
AC3 high voltage input module 12-1
AC3 input connectors 12-2
AC3 channel specifications 12-3
AC3 parameter-adjustment window 12-4

PART III

13 DATA CAPTURE
Data capture 13-1
Data capture control window 13-2
Triggering data captures 13-6
Core trigger 13-6
AM1 triggering 13-7
Dual sample rate 13-7
External sample rate 13-8
Data captures with multiple AstroDAQs 13-8
Notes features 13-9
Data capture with the host computer disconnected 13-12

14 RECORD MANAGEMENT
Record management 14-1
Record review 14-2
Markers feature 14-5
Reference capture feature 14-6
Record playback 14-8
Record maintenance 14-8
Archive to host 14-9

15 MONITORING REAL-TIME WAVEFORMS
Monitoring real-time waveforms 15-1
Setting up the monitor window 15-2
Selecting a waveform monitor format 15-3
Sweep speed and time-base resolution 15-4
Comparing waveform monitor to scope and review 15-5
Making measurements with waveform monitor 15-6
Saving waveforms on the host disk 15-6
Using the waveform setup window 15-8
Selecting X-Y plot format 15-9
Selecting meter format 15-10

Contents

16 MAKE TEST UTILITIES

Make test utilities	16-1
Adding and deleting channels	16-2
AstroLINK test sets	16-3
Custom keys	16-6
Restoring previous settings: last saved key	16-7

17 SEQUENCER WINDOW

Sequencer window	17-1
Running a sequence	17-2
Example sequence	17-3
AstroLINK sequencer script	17-4
AstroLINK sequence generator	17-4
Sequencer commands	17-5

18 ASTRO-LINK FILES

Initialization file (*.INI)	18-1
Configuration file (*.AMC)	18-2
View file (*.AMV)	18-3
Unit settings file (*.AMS)	18-3
Test set file (*.AMT)	18-3
Filter definition file (*.AMF)	18-4
Other files related to AstroLINK	18-4

19 NETWORK CONSIDERATIONS

AstroDAQ network addresses	19-1
Selecting network addresses	19-2
WatchDog timer	19-4
Use of phone lines and modem with AstroDAQ	19-5
Using the PC parallel port with the AstroDAQ	19-5
Connecting to UNIX-based computers	19-6

PART IV

20 **MAINTENANCE**

Applying AC power to AstroDAQ enclosures	20-1
Applying DC power to AstroDAQ enclosures	20-2
Changing the AstroDAQ's fuses or line voltage setting	20-3
Changing the AstroDAQ's battery	20-6
Updating the rackmount AstroDAQ's firmware	20-8
Updating the portable AstroDAQ's firmware	20-10
Using AstroLINK service menus	20-11
UTILITY port signals	20-13
Signal notes	20-14

INDEX I-1

PART I

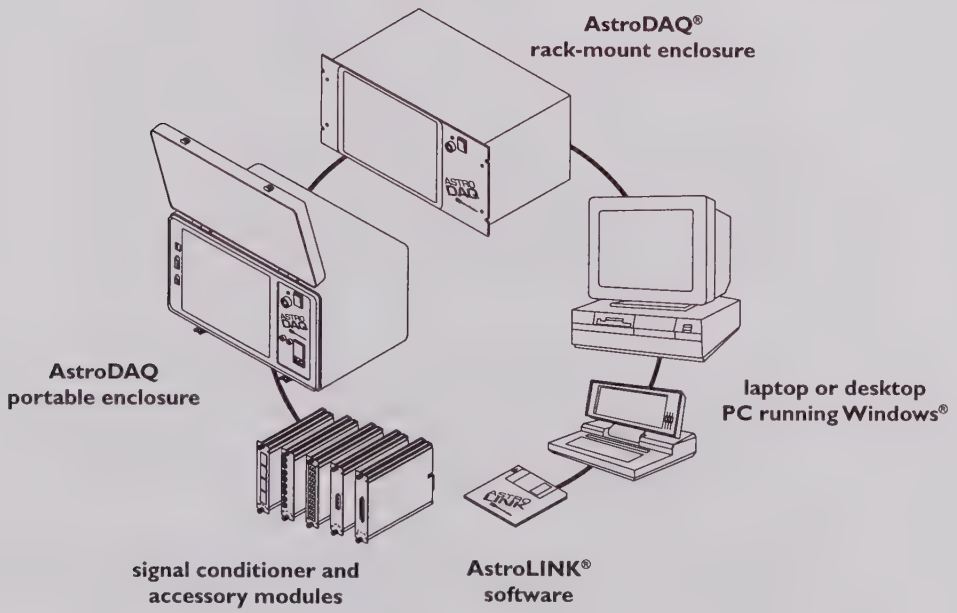
INTRODUCTION TO THE SYSTEM

1 SYSTEM OVERVIEW

Astro-Med's AstroDAQ® data acquisition system establishes new standards for power and ease of use in collecting real-world signals. The AstroDAQ System is a configurable set of hardware and software resources for the monitoring, acquisition, storage, and review of real-time signals, using a personal computer (PC) running the Windows® 95 or Windows for Workgroups operating system.

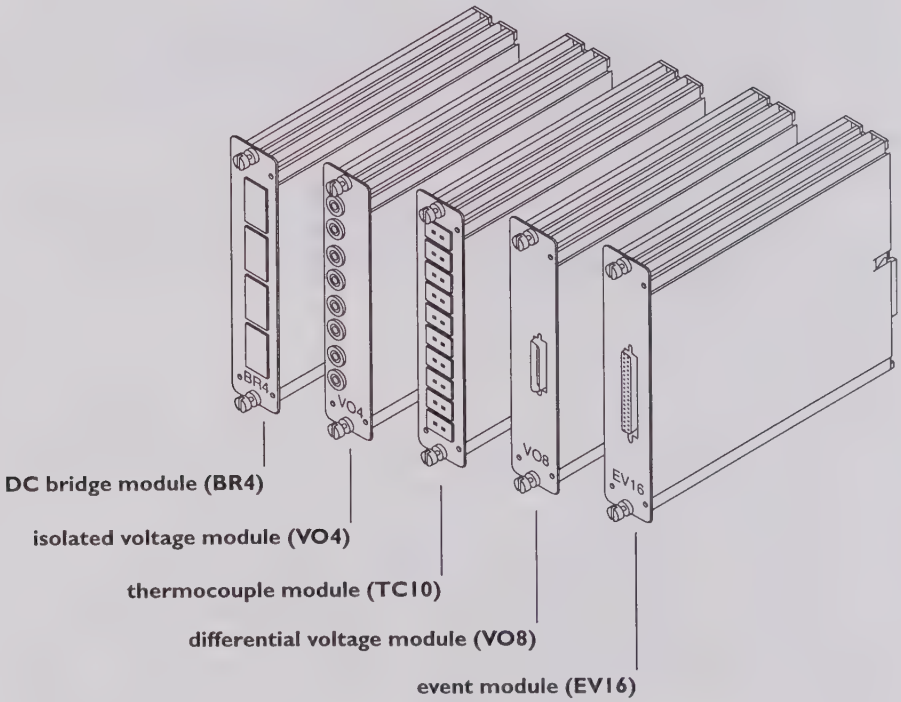
Unlike data acquisition systems that rely on the capabilities of the PC to collect waveform data, the AstroDAQ System incorporates its own powerful sampling hardware, high-capacity hard-disk storage, and advanced digital signal processing (DSP) features. The AstroDAQ System provides a single, seamless solution to the problem of acquiring real-world signals.

Shown below, the core AstroDAQ System consists of a multi-functional rack-mount or portable AstroDAQ enclosure, a complement of signal conditioning modules, Astro-Med's proprietary AstroLINK® software, and a personal computer with an Ethernet™ interface card.



Signal conditioner modules

Each type of signal conditioner module used in the AstroDAQ System is designed for a specific kind of signal input. Signal conditioner modules currently include the five types shown below. The AM1 accessory module, which is not a signal conditioner module, is described in section 11.



A typical signal conditioner module supports four to eight inputs although some modules can handle ten or more signals. All signal conditioner modules include a digital signal processor (DSP) and analog-to-digital conversion (ADC) circuitry. All sampling is performed by the modules, which greatly reduces the burden on the PC and ensures reliable sampling rates.

The output of all signal conditioner modules is a stream of numbers representing the sampled data. The sampled data is sent to the AstroDAQ enclosure where it can be stored on disk.

Signal conditioners for other purposes are continually being developed for use in the AstroDAQ System. Both the benchtop and portable versions of the AstroDAQ enclosure can support up to six signal conditioner and accessory modules.

Characteristics of the AstroDAQ enclosure

Each AstroDAQ enclosure has a single Ethernet connection to the PC. The Ethernet connection handles both command and data exchange.

The AstroDAQ enclosure includes data-capture hardware for the acquisition of sampled waveform data generated by the installed modules. Typically, data is stored on the hard disk built into the AstroDAQ enclosure. AstroDAQ enclosures can be equipped with hard disk capacities in excess of a billion bytes.

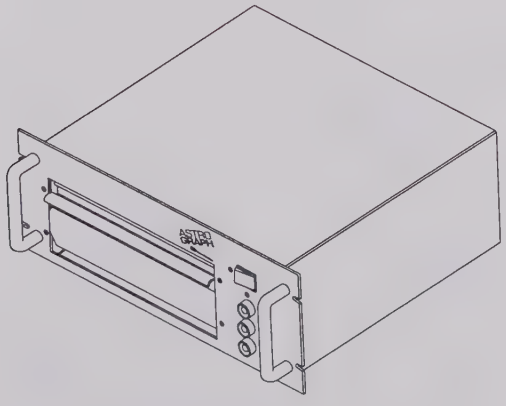
The AstroDAQ System has a maximum capture rate of 5 KHz per channel. This rate is independent of the number of channels being acquired. The AstroDAQ enclosure can also stream data to the PC, where it is used to generate real-time displays. Both portable and benchtop AstroDAQ enclosures can be operated from either AC or DC power sources.

Throughout this manual, the term "AstroDAQ" is used to refer to an AstroDAQ enclosure equipped with one or more signal conditioner modules. The term "AstroDAQ enclosure" refers to the enclosure without signal conditioner modules installed.

AstroGRAPH® chart recorder

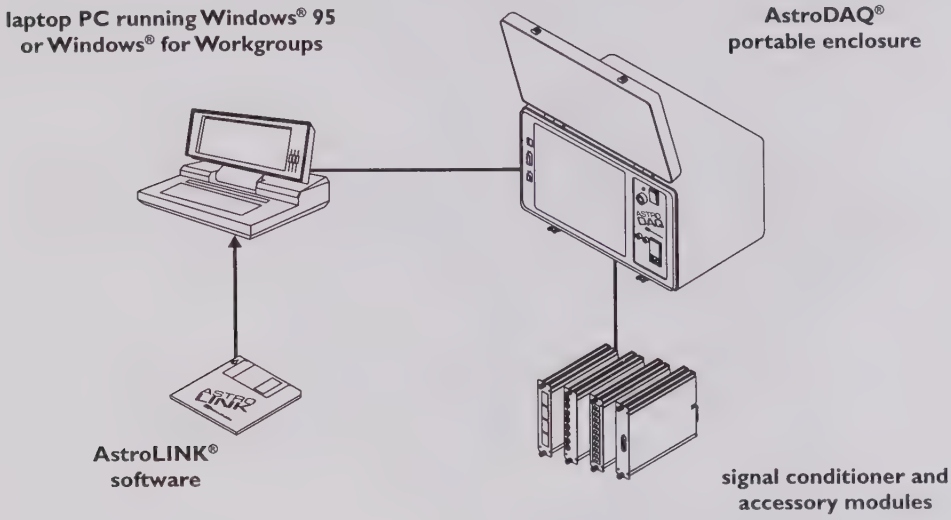
An AstroDAQ System can also be equipped with an optional high-resolution, real-time chart recorder called the AstroGRAPH. An AstroGRAPH recorder is shown in the illustration below. The optional AstroGRAPH chart recorder connects directly to a D-shell connector on the AstroDAQ enclosure. This frees all slots in the AstroDAQ enclosure for use with signal conditioner and accessory modules.

Refer to the *AstroGRAPH® User Guide* for more information.

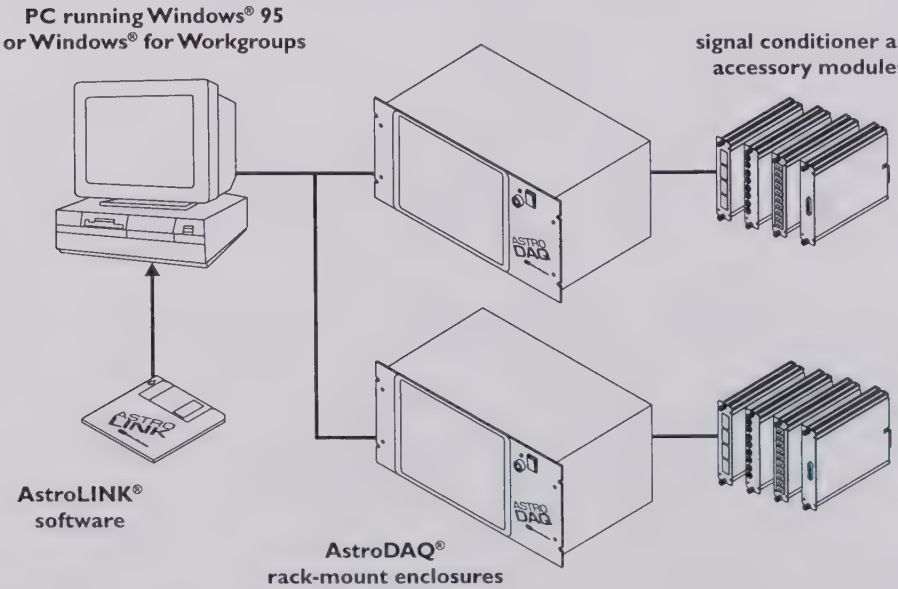


Examples of AstroDAQ System configurations

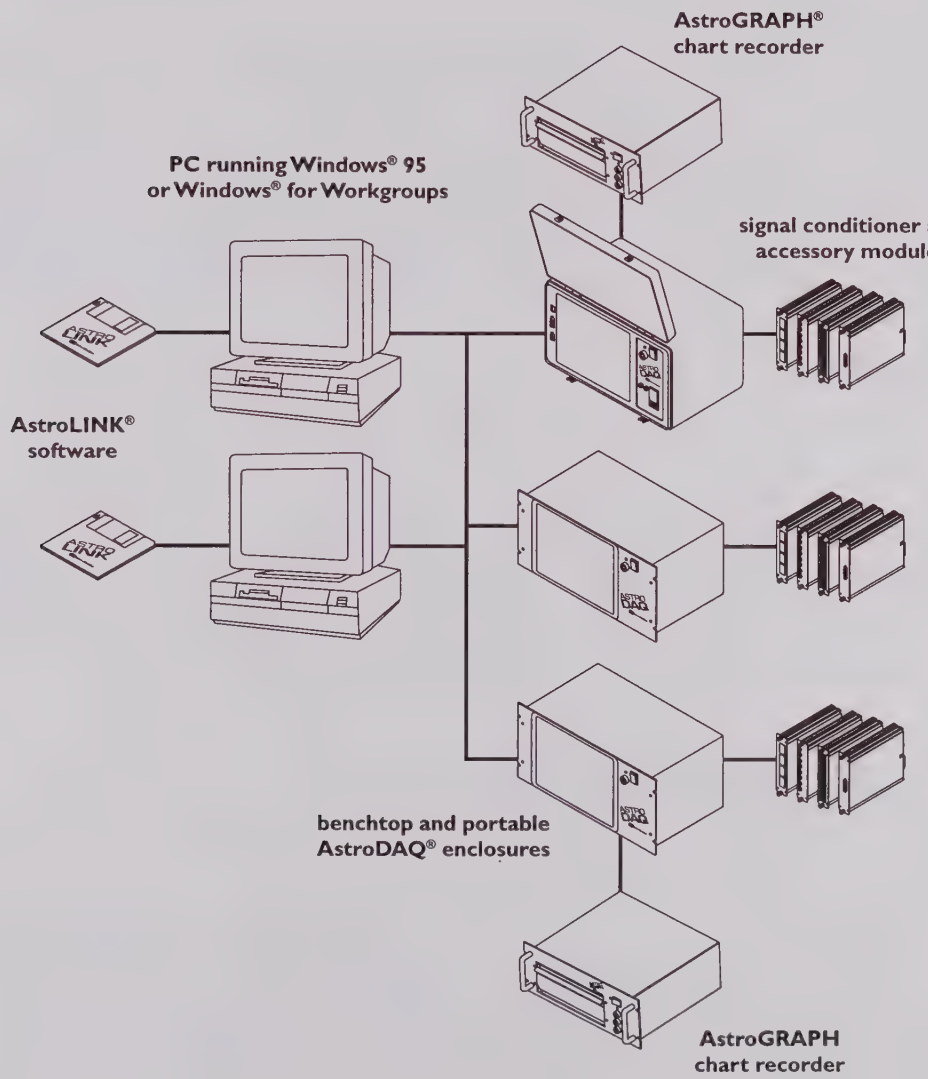
portable data acquisition for field work



manufacturing test cell



multi-user AstroDAQ system with AstroGRAPH chart recorders



Functions of the AstroDAQ System

It has already been stated that the purpose of the AstroDAQ System is to monitor and collect real-world signals. In collecting signals, the AstroDAQ system performs five functions:

1 Signal conditioning
2 Signal monitoring (or chart recording)
3 Data sampling and primary storage
4 Data review
5 Final storage of selected samples using industry standard formats

These functions are accomplished using AstroDAQ hardware and the basic AstroDAQ software package, AstroLINK. AstroLINK runs under Windows 95 or Windows for Workgroups and implements most functions through point-and-click mouse movements.

Signal conditioning function

As previously indicated, a variety of signal conditioner modules are available for use in the AstroDAQ System. Each signal conditioner is optimized for a particular class of input signals. The capabilities of each signal conditioner are unique and specific to the conditioner's function. As necessary, AstroLINK software supports each module with set-up menus specific to the function of the conditioner. Most signal conditioner parameters can be adjusted 'on-the-fly.' Alternatively, the parameters can be set up in advance and implemented with a single mouse click.

Signal monitoring function

Monitoring signals in real-time provides the assurance that the test is going as designed and alerts the user to changes.

Recognizing the importance of signal monitoring, the AstroLINK software package provides two multi-channel color monitor windows. Each window can be customized to suit the application. The optional, high-resolution AstroGRAPH chart recorder provides the added capability of continuous, real-time hard copy in parallel with the waveform acquisition process.

- **Triggering**

A part of the signal monitor function that is not always appreciated is triggering. This refers to the ability of a system to detect when the signals are in a specific state. The AstroDAQ System has a powerful set of trigger generation features that allow waveform acquisition to be optimized.

- **Analog outputs**

An additional means of monitoring signals is provided by four analog outputs. Each output can be set to represent any active input.

Data sampling and primary storage

The AstroDAQ System does not use the resources of the personal computer to collect waveform data. Instead, the system uses conversion circuitry and storage capacity built into the Astro-DAQ enclosure and the signal conditioner modules themselves. This ensures that the selected sample rates are always obtained regardless of the number of installed signal conditioner modules or the state of the PC.

AstroLINK software menus provide full control over sampling rates. AstroLINK also provides a variety of methods for starting and stopping data acquisition. Data collection can be interactive or based on pre-set parameters. Collection can be initiated with a single mouse click.

Data review

The design of the AstroDAQ System assumes that not all collected data is useful. As a result, the System provides efficient tools for scanning the acquisition before it takes up space in the PC. These tools include:

- a graphic display for visual review of acquired data
- interactive tools for quantifying acquired data.

Waveform data saved on the AstroDAQ enclosure's hard disk remain on the disk until erased. This eliminates the need to save everything on the PC.

Conversion to popular formats

A second important design assumption of the AstroDAQ System is that acquired data must be available for input into third-party spreadsheets and report generators. To provide this capability, the AstroDAQ System uses conversion routines to save the waveform data in formats compatible with these packages. Selected portions of any acquisition can also be sent to the Windows clipboard. For hard copy with a more traditional appearance, acquired data can be sent to the AstroGRAPH chart recorder.

2 SYSTEM SPECIFICATIONS

Specifications for AstroDAQ data capture, signal conditioner modules, triggering, AstroLINK, and system hardware and operating requirements are provided in this chapter.

Data capture

total sample rate	150,000 samples/sec
maximum samp rate per channel	5000 samples/sec/channel
minimum rate per channel	0.1 sample/sec/channel
maximum waveforms	30
maximum events	64
amplitude resolution	16 bits
internal storage	1 Gbyte hard drive
capacity	1000 records
time stamp	time and date automatically saved with data
header	information on units, range, sample rates, etc. saved with data
dual sample rate	independent control over pre-and post-trigger sample rates
external sample rate	external TTL sample clock to 1000 Hz 300 microsecond minimum pulse width

Signal conditioner modules

capacity	maximum of six modules; typically 4 to 10 channels per module
types	voltage, bridge, thermocouple, etc. refer to module sections 5 - 12 for details
DSP	each module includes a digital signal processor

Trigger

standard	any active waveform channel (level/slope); acquisition can be a mix of pre-and post-trigger data
AM1 option	event or window trigger on 30 channels; four slew-rate / inside window channels four TTL inputs

AstroLINK software

description	software to control ten AstroDAQs and review acquired data
environment	PC with Windows 95 or Windows for Workgroups and Ethernet
functions	module and acquisition setup menus; data review capability with cursors and measurement tools; archive original data or as ASCII files in engineering units

Other features

host interface	Ethernet (TCP/IP) for control of data
analog outputs	any four active waveforms (adjustable to 10V span)
chart recorder output	direct connection to optional AstroGRAPH chart recorder (300 dpi)

Power

input voltage	120 VAC or 240 VAC 11 VDC to 20 VDC
operating current	120 VAC; 0.5 A typical; 1 A maximum 12 VDC; 5 A typical; 12 A maximum
battery backup	2.5 Ahr battery with charger is standard; full operation for 5 minutes is typical

Physical

dimensions	rack, without handles: 28 x 48.2 x 23 cm (11 x 19 x 9 in) portable: 33 x 44.5 x 25 cm (13 x 17.5 x 10 in)
weight	rack, without modules: 8.2 kg (18.2 lb) portable without modules: 10 kg (22 lb) typical module: 0.4 to 0.9 kg (1.5 to 2 lb)

Environmental

operating temperature	0° to 42° C (32° to 107° F)
non-operating temperature	-15° to 60° C (0° to 140° F)
operating humidity	5% to 90% non-condensing
elevation	3,000 meters (10,000 feet) maximum

Shock/vibration

Shock and vibration values apply only to the portable AstroDAQ.

operating, no data loss	10 G shock (half sine, 11 msec) in any single axis; random vibration from 5-200 Hz to a maximum of 0.5 G (rms) in any single axis
non-operating, no damage	25 G shock (half sine, 11 msec) in any single axis; random vibration from 5 -200 Hz to a maximum of 0.8 G (rms) in any axis; sinusoidal vibration from 5-200 Hz to a maximum of 1 G in any axis

AstroDAQ signal conditioner modules

name	input type	inputs	resolution	maximum range	special features
AC3	AC voltage	3	50 mV	peak-to-peak: ± 850 V RMS: 0 to 600 VRMS frequency: 0 to 1000 Hz	
BR4	isolated DC bridge	4	0.02 mV/V	100 mV/V	filter, auto bal
BR4H	isolated DC bridge	4	0.002 mV/V	10 mV/V	filter,auto bal, high gain
CO8	binary events	8		-5 to 8 V**	counter, rate meter
EV16	binary events	16		-5 to 60 V**	optically coupled
EV16A	high voltage signals	16			
TC10	thermocouple	10	0.25° C	-100° to +1200° C	J, K, E, T, linearized
VO4	isolated voltage	4	0.25 mV*	±400 V	d/dt, integrate, filter, RMS
VO8	differential voltage	8	0.8 mV	±20 V	d/dt,integrate, filter, RMS
VO8H	differential voltage	8	0.1 mV	±2 V	d/dt, integrate, filter, RMS, high gain

*** 20 mV for ranges above ± 6 V**

**** higher voltages possible with resistor change**

AstroDAQ accessory module

name	function
AM1	provides advanced triggering capabilities and user configurable I/O which can be used to automate the test process Features include: • 30-channel window triggering • event triggering • four slew rate triggers* • AND / OR logic for triggers I/O capabilities include: • two isolated relays • four digital inputs • four digital outputs • two voltage level outputs • a clock output (50,000 Hz maximum)

***Astro-Med offers an AM2 accessory module which includes 30 slew-rate triggers, but provides no hardware inputs and outputs. Contact Astro-Med Technical Support at 1-800-343-4039 for further information.**

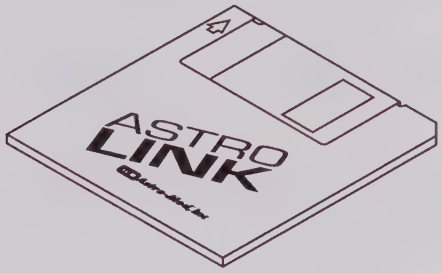
Regulatory compliance

FCC Class A
CISPR 11 Class B
UL 3101
CSA 1010
IEC 1010

3 ASTROLINK SOFTWARE INSTALLATION

Astro-Med's AstroLINK software is supplied on 3.5-inch floppy disks and must be installed on a personal computer running either the Windows 95 or the Windows for Workgroups operating system. The AstroLINK software installer program simplifies and automates the installation of AstroLINK. The installation process requires and assumes a valid Windows operating environment and at least eight megabytes of free memory. See the detailed installation instructions in the *AstroDAQ® Installation Guide.*

AstroLINK uses the TCP/IP protocol for communications. If the network card is not supplied by Astro-Med, the TCP/IP protocol must be installed by the user. Astro-Med can provide technical support for this step as required.



Connecting an AstroDAQ to a network

The host PC to which the AstroDAQ will be connected must have a network card with an RJ-45 connector. If the PC is a desktop model, the network card is generally installed inside the computer with the card's hardware connector available at the computer's rear. If the PC is a laptop model, the network connection is often provided by a PCMCIA card that features a network hardware connector. In either case, connect the network cable both to the PC's network connector (or hub) and the network connector on the AstroDAQ enclosure.

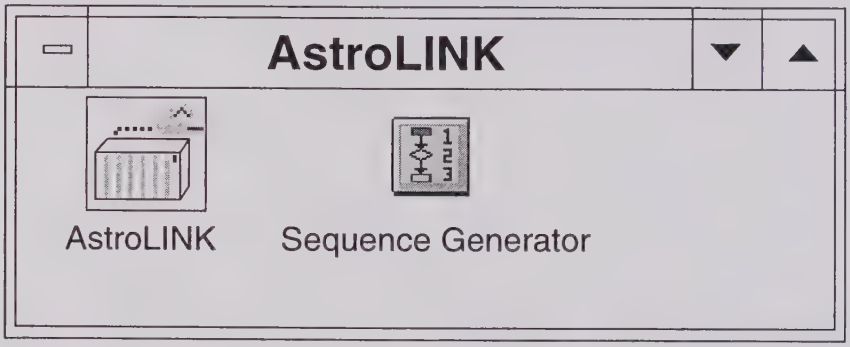
The network connection on the AstroDAQ enclosure is labeled "NETWORK." The network connection is located at the rear of rack-mount AstroDAQ enclosures and on the front panel of portable units.

When the PC is connected directly to an AstroDAQ enclosure, a special version of the network cable is required. A straight-through network cable will not work. The special version of the network cable is available from Astro-Med. See the detailed instructions on network connections in the *AstroDAQ® Installation Guide.*

Starting the AstroLINK software

When AstroLINK is installed properly under Windows 95, it can be launched by selecting START > PROGRAMS > AstroLINK. This causes the AstroLINK splash screen to appear.

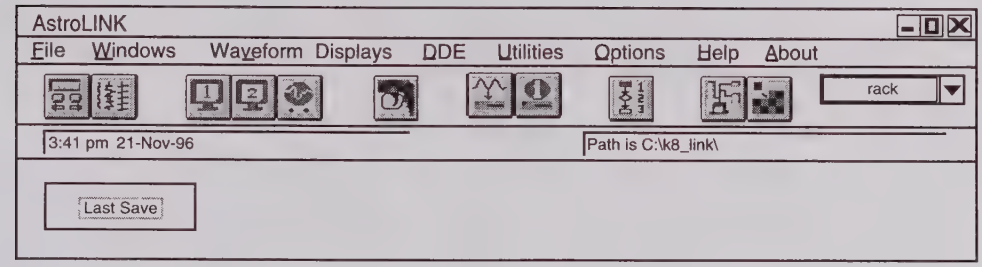
When AstroLINK is installed under Windows for Workgroups, the AstroLINK icon is present in the Program Manager window. To launch the AstroLINK application, double-click the AstroLINK icon.



During AstroLINK initialization, the following splash screen is displayed. The last line of the display is dynamic and changes to note the progress of the initialization.

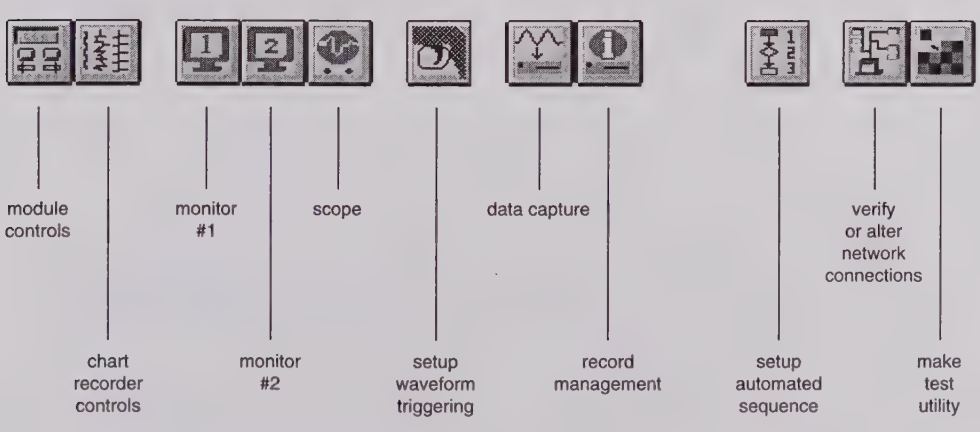
The first time AstroLINK is run after installation, it will not attempt to connect to any AstroDAQ. As described in this section, AstroLINK's Configuration menu is used to add AstroDAQs.

If AstroLINK encounters no critical errors after launch, the program will open to the following window.



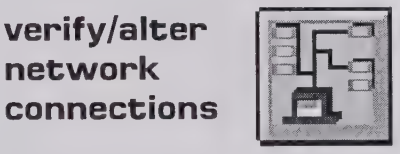
The lower right message block of the AstroLINK main window shows the current User Path. The lower left message block provides additional information.

AstroLINK functions are accessed by clicking on the individual icons on the main window tool bar. When the cursor is moved over any of the icons, a description of the icon's function is shown in the lower left message block. The icons in the tool bar are identified below.

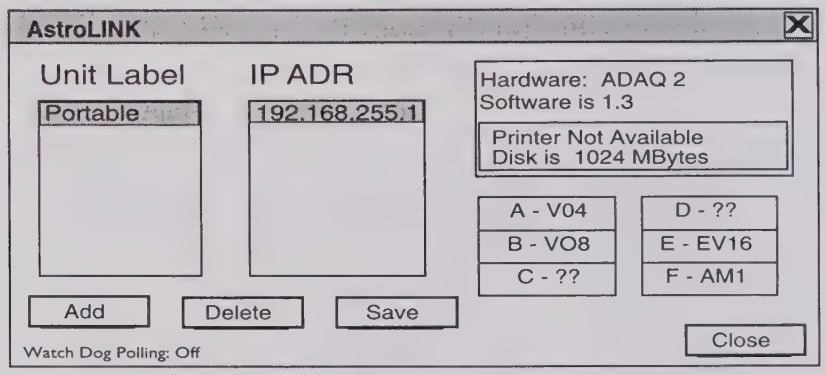


Adding an AstroDAQ

The network connections utility icon is used to confirm or change the AstroDAQ System network connections. The icon shows a PC with several attached AstroDAQs.



If AstroLINK has made a network connection, the configuration window (shown below) will list the unit label and IP address of the unit. If no AstroDAQs are connected, the Unit Label and IP ADR list boxes will be empty.



To add an AstroDAQ to the AstroLINK network, click the Add button in the bottom portion of the configuration window. Prompts lead to the entry of an eight-character, user-definable Unit label and the required IP address. When entering the IP address, typographical periods (.) must be in the correct location (e.g., 192.168.255.1).

When the IP address has been entered, AstroLINK will immediately attempt to connect with the specified AstroDAQ. If the AstroDAQ is successfully connected, it is added to the list of active AstroDAQ connections. The contents of each slot in the newly connected AstroDAQ are shown on the configuration window. Additional information regarding any individual module is available by clicking the module name.

If AstroLINK cannot connect to the AstroDAQ: 1) push and hold the CLEAR button on the front of the AstroDAQ for two to three seconds, and; 2) repeat the AstroLINK connection procedure described above.

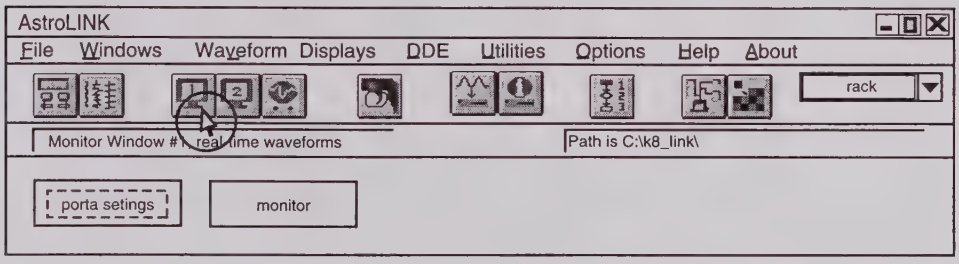
When the AstroDAQ has been added to the network configuration, the user is ready to proceed. If the newly defined hardware configuration will be used again, the configuration can be saved to an "*.amc" file using the Save button at the bottom of the configuration window. If the configuration is saved to the file config.amc, the file becomes the default configuration file.

Each AstroDAQ connected to a network must have a unique IP address. In most cases, the IP address is determined by jumper settings on the AstroDAQ mother board. Unless the IP address of an AstroDAQ is known, the AstroDAQ cannot be used. The IP address is changed only under special circumstances. See the detailed information on IP addresses in chapter 19 of this guide.

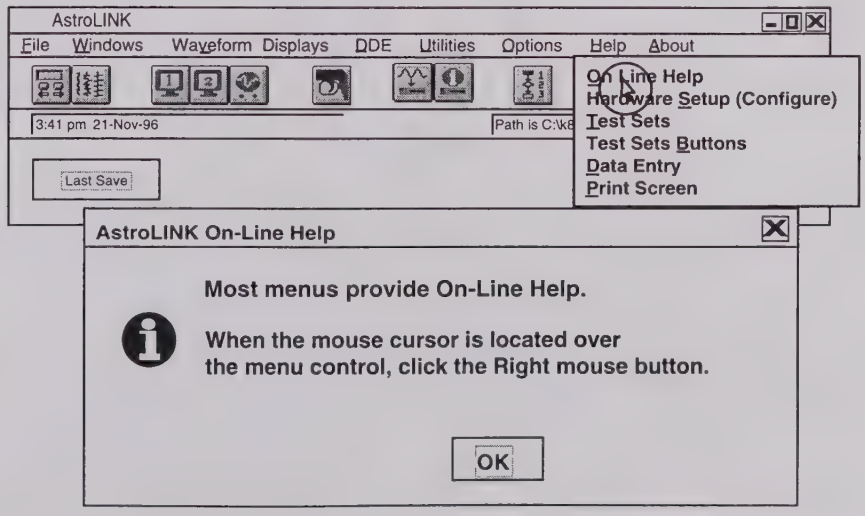
HELP functions

AstroLINK offers extensive on-line help. Three methods of accessing on-line help are described below.

1 Float the cursor over each icon in the main window to see a description of the icon in the left-most information block beneath the tool bar.

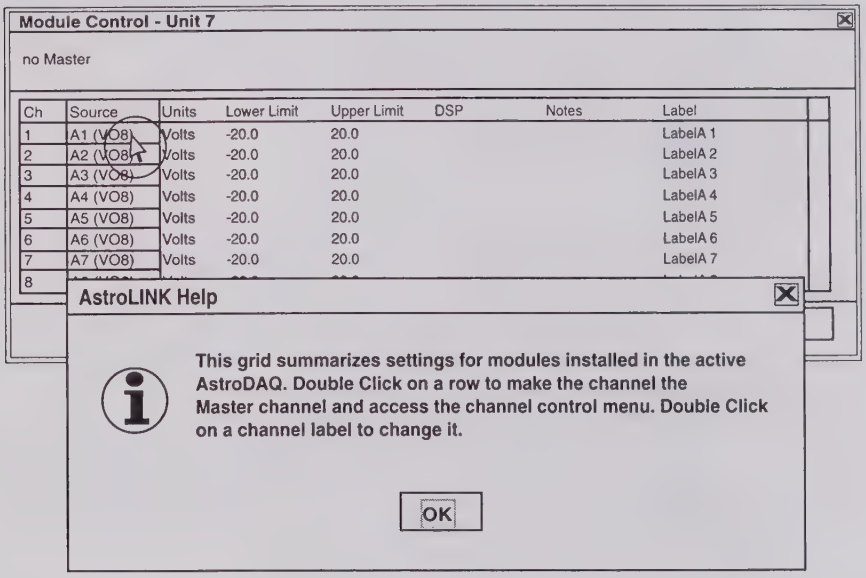


2 Click Help in the main tool bar to access several help sub-menus as shown below.



3 Float the cursor over window fields and click the secondary mouse button (usually the right button) to call up individual help screens related to the ongoing function.

- the help screens are extensive but not every field of every window has an associated help screen.



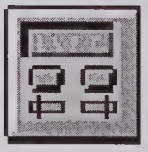
DDE capability

The AstroLINK main window includes a DDE (dynamic data exchange) menu option. DDE is a technique developed by Microsoft which permits data exchange between Windows applications. DDE between two applications is described as a DDE conversation. The application that initiates the conversation is called the **client**, while the responding application is the **server**.

In AstroLINK versions 1.2 and higher, a DDE server is provided that takes the place of the Monitor and Scope functions. To learn more about the DDE server and how to use the DDE capability, please contact Astro-Med Technical Support and ask for the Application Notes related to the AstroLINK DDE Capability.

Module Control window

Click the Module Control icon to open the Module Control window (shown below).



module
controls

Module Control - Unit 7

no Master

Ch	Source	Units	Lower Limit	Upper Limit	DSP	Notes	Label
1	C1 (VO8)	Volts	-20.0	20.0			LabelC 1
2	C 2 (VO8)	Volts	-20.0	20.0			LabelC 2
3	C3 (VO8)	Volts	-20.0	20.0			LabelC 3
4	C4 (VO8)	Volts	-20.0	20.0			LabelC 4
5	C5 (VO8)	Volts	-20.0	20.0			LabelC 5
6	C6 (VO8)	Volts	-20.0	20.0			LabelC 6
7	C7 (VO8)	Volts	-20.0	20.0			LabelC 7
8	C8 (VO8)	Volts	-20.0	20.0			LabelC 8

Close

The Module Control window summarizes the current setting for every active channel. In AstroDAQs with more than thirty channels installed, active channels are selected during the design of the test conditions. When many channels are active,the vertical scroll bar to the right of the channel list is used to scroll through the active selections.

The channel numbers displayed in the Module Control window are assigned to active channels during the test design process (using the Make Test utility). The channel number is used as a reference on many menus but has no direct relationship to the physical waveform input.

The column labeled "Source" locates the physical signal input. Each of the six module slots of the AstroDAQ enclosure is assigned a letter from A to F. The letter "A" represents the leftmost slot. The signal inputs for each module are numbered starting with "1." Generally, module inputs are numbered from top to bottom with reference to the input connector.

The sample window on the previous page indicates that a V08 module is located in slot C. The eight inputs of the V08 are active because all eight inputs are listed. Channel 1 is assigned to the input signal C-1. If a module were installed in slot A and the channels were active, channel 1 would no longer be assigned to the input signal C-1.

The "Units," "Lower Limit," and "Upper Limit" columns indicate the current settings for the channel's range. This range will represent full scale on a monitor screen or chart recording.

In addition to summarizing the current settings for each channel, the Module Control window is used to access the Parameter-Adjustment window for each module. The Parameter-Adjustment window is used to modify the settings shown in the Module Control window and is specific to each type of module. Examples of Parameter-Adjustment windows are provided with each module description in chapters 5 through 12.

The channel label can be changed by double-clicking on the Label column in the Module Control window.

Scope tool

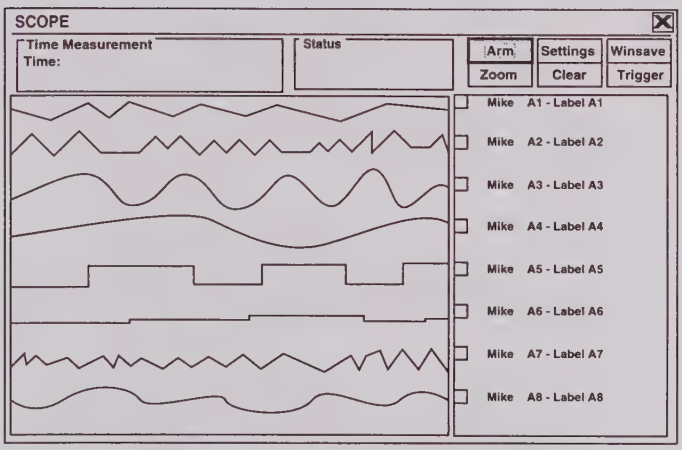
After channel connections and signal conditioning have been established, acquisition and review of waveform data can begin.

Although the primary tools associated with data acquisition and review are Data Capture Control and Record Management, the Scope tool (with minor restrictions) combines capabilities for the capture, review, and archiving of data.

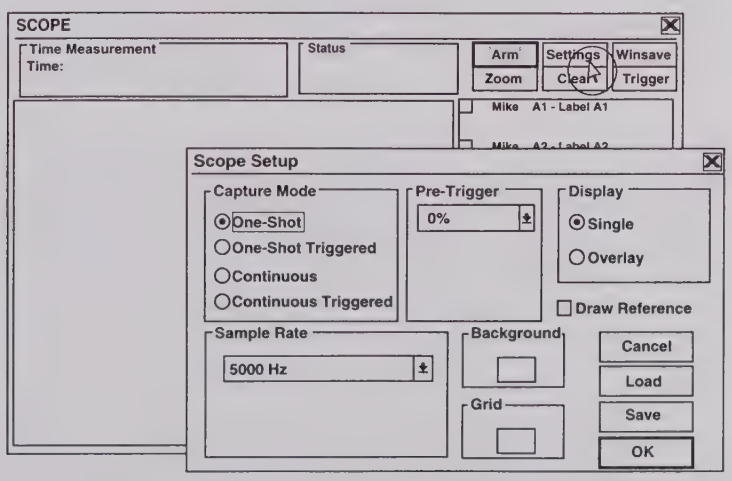
As the name "Scope" indicates, the Scope tool performs the role of a Digital Storage Oscilloscope (DSO). Scope controls are generally oriented to the quick visualization of signals.

Click the Scope icon to open the Scope window (shown below).

**scope -
waveform capture
and display**



The buttons in the upper right of the Scope window control the Scope function. Initially, it is necessary to verify that the Scope is properly setup. Begin by clicking the "Settings" button to open the Scope Setup window.



The sample rate is listed in the Sample Rate selection box in the lower left of the window. Although designated in Hz, the sample rate can be thought of as samples per second per channel. The pull-down list provides the sample rate choices. *The Scope function does not provide as many sample rate choices as the Data Capture Control window.*

The Capture Mode selections determine the way in which the Scope function will operate:

- *One-Shot* - the Scope will capture signals, display them, and wait for further instructions.
- *Continuous* - the Scope will capture signals, display them, and begin the capture of another set of signals.

Selecting "Continuous" results in a constant sequence of displays, with each display remaining on-screen until another set of waveforms is captured. If the selection is triggered, the capture phase continues until a trigger is detected. Triggers can be based on waveform state or can be manual. Manual triggers can be generated by the Trigger button in the Scope window.

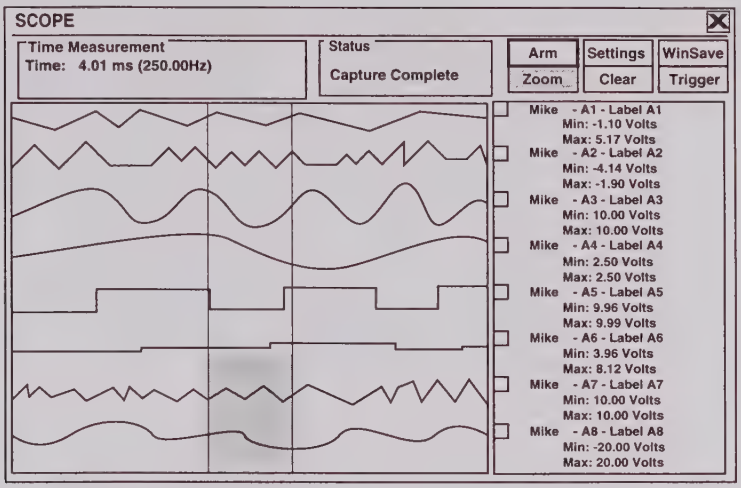
If a triggered mode is selected, the "Pre-Trigger" control becomes active. The pre-trigger control is used to specify the portion of the capture to be taken before the trigger event occurs. *As with traditional oscilloscopes, the "Continuous Triggered" mode can be used to synchronize the waveform display with some event.*

To further explore the functions of the Scope capability, select "One-Shot" (not triggered) and "Single Display." Ensure that the "Draw Reference" selection is unchecked. Click OK to return to the Settings window. The Cancel button aborts any changes that may have been made.

To start a capture, the Arm button must be clicked. The time required to complete a capture depends on the sample rate. During slow captures, a message indicating that a capture is in progress is displayed. Having worked with the Scope window to this point, it is instructive to run the Scope with real signals at varying sample rates.

WARNING: While the Scope is running, the Module Control window can remain open. This allows signal conditioner settings to be adjusted and provides an excellent way to gain experience with the signal conditioners. However, *adjusting conditioner settings will erase the current Scope data.*

After a capture has occurred, the Scope window will look similar to the illustration below.



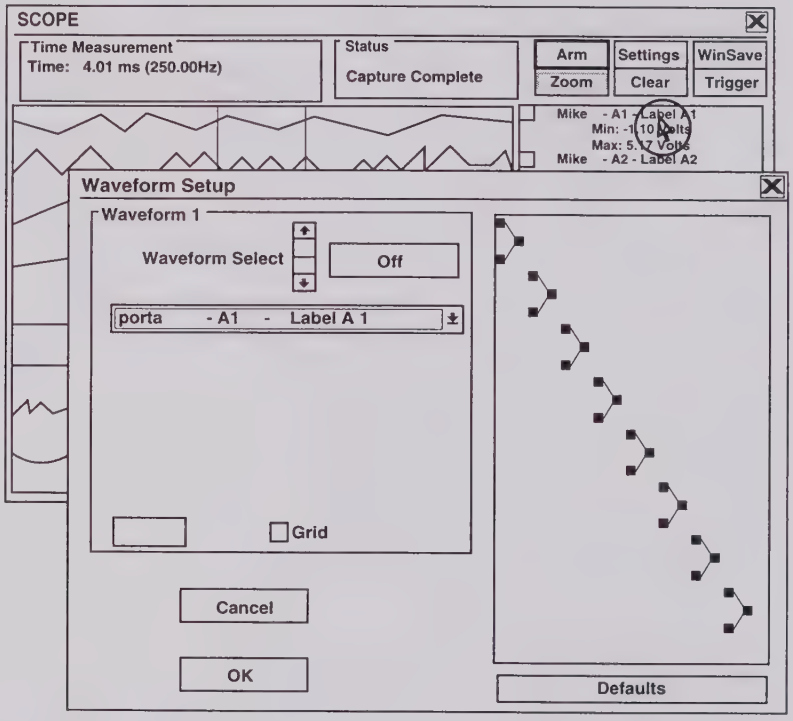
The Scope function provides the same capacity to quantify displayed waveforms as some other AstroLINK waveform displays. To quantify waveform data after a capture is complete:

1 Move the cursor over a section of the waveform.
2 Click the mouse, hold it down, and drag it along the time axis.
3 Release the mouse to see the value of all displayed signals in engineering units on the right side of the window.

The illustration above shows the result of this kind of data selection. The quantified data shows the minimum and maximum signal values over the period of time specified. The upper left of the display shows the time period selected. The inverse of the time period is displayed as Hz when the selected area represents a single cycle.

The two long vertical lines indicate the measurement time period. The highlighted area within this region will be expanded to fit the full window when the ZOOM button is clicked. The UNZOOM button is clicked to return the screen to normal. The cursors can be used to make measurements while in the ZOOM view, but a zoomed display cannot be further expanded.

The format of the display can be changed at any time. To change the display, click the left mouse button over any of the channel text fields on the right of the Scope display. The Waveform Setup window (shown below) will appear.



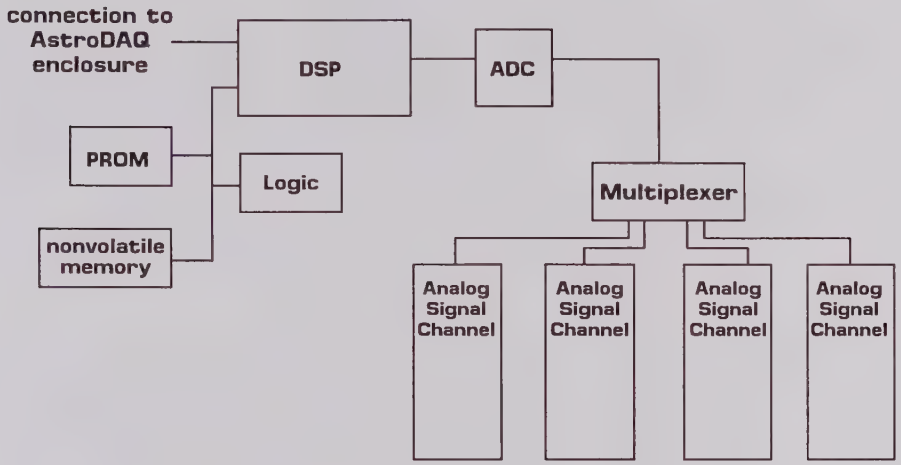
In the Waveform Setup window, the graphic display on the right is used to change the physical size and location of the displayed waveforms. Changes are made by clicking and dragging on the waveform anchor blocks. Generally, these blocks are color coded to simplify waveform identification. The colors used for the waveforms are user-selectable. The Scope function provides a good mechanism for experimentation with color selection control. The ability to specify the color scheme of choice is a feature common to all AstroDAQ waveform displays.

The Scope function provides a variety of features that are representative of AstroDAQ capabilities. These include:

- the ability to save displayed signals to the PC in a variety of standard formats
- the ability to save signals as a reference that can be displayed in association with new signals
- the ability to save the display format for later use or recall

4 ASTRODAQ MODULES: GENERAL INFORMATION

Typically, AstroDAQ signal conditioner modules share the component relationships shown in the block diagram below.



A digital signal processor (DSP) handles all commands and data flow to the AstroDAQ enclosure. The DSP also collects data from the analog-to-digital converter. The data is processed in accordance with user instructions and calibration factors maintained in local nonvolatile memory. All local software is stored in PROM. As a general rule, the DSP implements real-time numeric functions such as filtering, RMS, and integration.

The four-channel arrangement shown in the illustration is typical but some modules can support as many as sixteen signal inputs. Generally, the analog signal paths on a module are identical to one another. Each signal path ends with a low-pass filter that prevents sampling errors due to aliasing. DSP sample rates vary with the module type.

About the waveform path in AstroDAQ Systems

The primary function of an AstroDAQ System is the acquisition of analog waveforms. The discussion that follows concerns the process by which waveforms move through an AstroDAQ system.

Waveform broadcasting in the AstroDAQ System

Real-time waveform data is moved from the module to the AstroDAQ enclosure over a proprietary, high-speed bus. The bus has time slots for thirty sequential waveforms. Each waveform is associated with a channel number.

A full AstroDAQ enclosure bus cycle has time slots for 30 sequential waveforms. The order of the waveforms is determined by the channel number. A full cycle occurs every 200 microseconds. This means that any single channel is broadcast over the bus at a rate of 5000 samples per second (5 KHz). It is important to distinguish between the broadcast rate and the module DSP sample rate as follows:

- The broadcast rate is always 5 KHz. The module DSP sample rate may be greater than or less than 5 KHz. Each sample is a full 16-bit word with a potential range from -32500 to +32500.

Each module must be assigned a channel number for every signal to be broadcast. In AstroDAQs in which more than 30 channels are available, AstroLINK's Make Test utility is used to select the channels that will be broadcast. Signals that are not broadcast are not available to other AstroDAQ components and are effectively disabled.

Anti-alias filtering and channel bandwidth

Before reaching the multiplexer, analog inputs are conditioned and band-limited by hardware anti-aliasing filters. An anti-aliasing filter is a low-pass filter designed to ensure that signals too fast to be sampled properly are reduced in amplitude and, consequently, unable to affect the measurement.

Generally, AstroDAQ signal conditioner modules have two levels of filtering:

- Level 1 - the hardware anti-alias filter already described
- Level 2 - a digital filter implemented by the module DSP

Unless otherwise indicated, bandwidth specifications for AstroDAQ signal conditioner modules include both filters. Channel bandwidth is specified in terms of the -3 dB point. This is the frequency point at which signal amplitude is attenuated to approximately 70% of its original value.

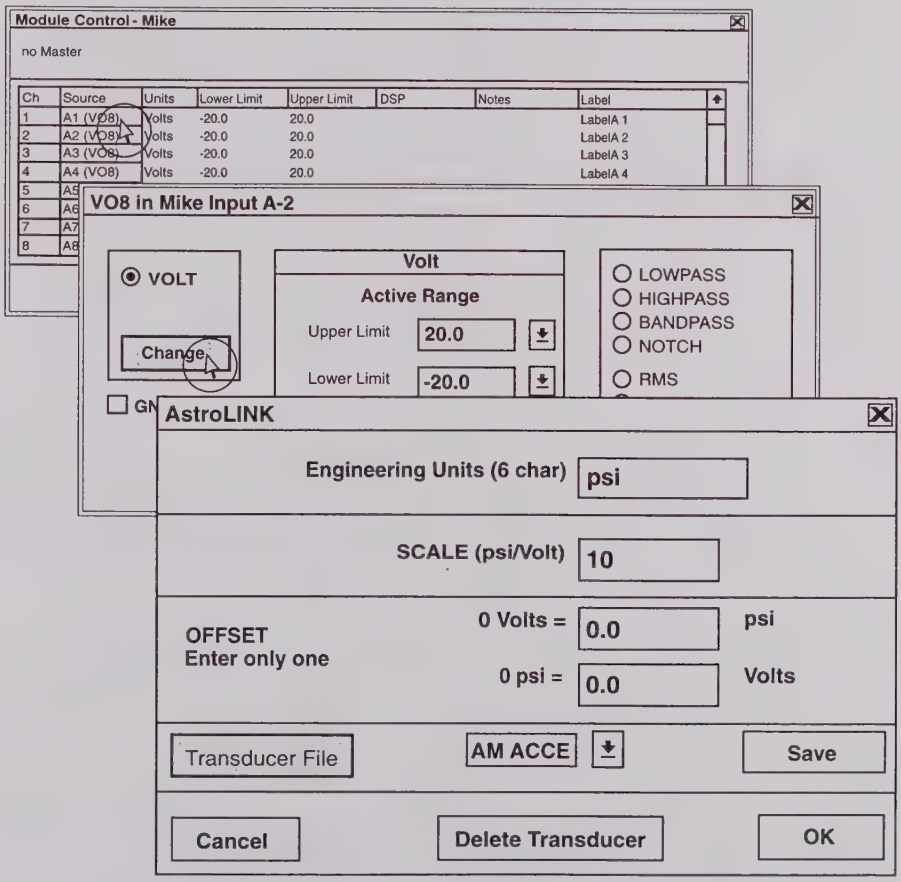
The ability to specify the true effective bandwidth is an advantage that the AstroDAQ System has over data acquisition systems that depend on the host computer to sample the data. Where sample rates cannot be guaranteed, the true effective bandwidth cannot be guaranteed.

Specifying user engineering units

AstroDAQ waveform modules are calibrated in units appropriate to the module. These are referred to as the module unit. In the case of V04 and V08, the module unit is Volts. In the case of the TC-10, the module unit is degrees Celsius.

AstroLINK provides a mechanism for converting the module unit to a user engineering unit specified by the user. When assigned, the user engineering unit replaces the module unit in all displays and recordings. Acquired waveform data is specified in user engineering units when saved as an ASCII file.

The relationship between the module unit and the user engineering unit is assumed to be linear, characterized by a slope and offset (e.g., y = mx + b). The menu shown below is used to specify this relationship.



The example above is based on a user-supplied transducer that converts pressure to volts. It is connected to a V08 that uses volts as the module unit. The transducer has no offset and generates 1 volt for every 10 psi.

When using this menu to define a user unit, note the following:

- SCALE is the waveform change in user units that is equivalent to one module unit.
- OFFSET can be specified either as the number of user units that are equivalent to zero module units or the number of module units that are equivalent to zero user units. Only one entry is required. The other is derived automatically.

When scale and offset have been specified, the OK button is clicked. If a particular user unit will be used frequently, the unit can be saved on the host computer in the transducer file. This is a set of scale and offset values that are each associated with a user-defined name and number.

Event processing

An event is a special type of waveform that has only two states of interest. Traditionally, event sources were associated with relays but it is now common to record digital logic levels with analog waveforms. Most digital logic levels are TTL-compatible. TTL compatibility means that the logic levels switch from approximately zero (0) volts to between 2.5 and 5 volts. This is an ideal signal for most data acquisition systems because it can be used without signal conversion.

When using a relay driver circuit, the voltage levels that correspond to Low and High states vary. Generally, a Low (relay open) is approximately 0 volts and a High (relay closed) is a positive voltage from 3 to 24 volts. This type of event must be conditioned before it can be recorded by a digital data acquisition system.

Either of these two event sources can be treated as voltage waveforms by the data acquisition system. When a V04 signal conditioner module or a V08 signal conditioner module is used to acquire such signals, the event signals follow the waveform path already described. Because only two states are of interest, the resolution of the analog waveform input is wasted. However, the measurement process is simplified and makes sense when only a few events are involved.

To support requirements for larger numbers of event channels, the AstroDAQ provides a special mechanism packing sixteen event signals on a single waveform channel. This permits the design of cost-effective modules and reduces the number of waveform channels that must be broadcast.

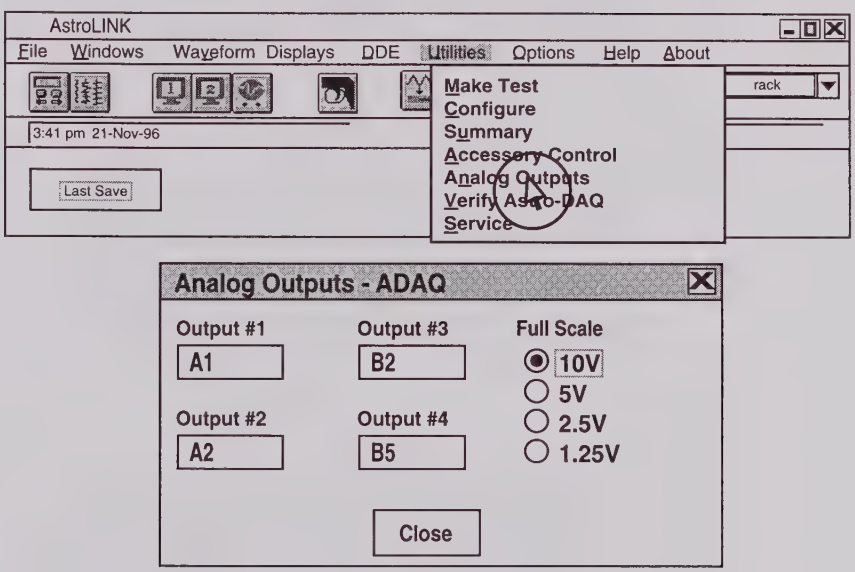
The EV16 module was designed to acquire 16 events using this special mechanism. Each EV16 installed in an AstroDAQ enclosure is listed as a single channel on the Module Control channel list of AstroLINK. A maximum of sixty-four events can be broadcast at one time (four channels).

The AM1 module can be configured to produce three event channels (the third event channel is reserved). These represent the thirty trigger windows provided by the module. Refer to chapter 11, AM1 accessory module, for more information.

Analog outputs

Each AstroDAQ enclosure provides four analog outputs. Refer to the Utility Port discussion in chapter 20, maintenance, for pin-out information. Each analog output can be configured to represent any one of the active waveforms. The range of the outputs is selectable from 1.25 to 10 volts. The analog output represents the fully processed input waveform including any filtering or special processing, such as RMS.

Select "Analog Outputs" from the Utilities pull-down menu to open the Analog Outputs dialog box (shown below).



Analog outputs are only available when one of the following is active: Monitor, Scope, Data Capture, Sequencer.

Module specifications

The specifications published for any specific amplifier are only valid if the input does not exceed the range of the amplifier.

- **input impedance**

Input impedance is a measure of the loading effect of the amplifier on the voltage source. Input impedance is specified in ohms and generally ranges from 100 kilohms to 2 megohms. Although the significance of input impedance depends on the impedance of the source, a higher input impedance generally is desirable. If the source impedance is adequate, a measuring device with very high input impedance may not perform as well as another. This is because the device is more likely to pick up noise from the environment.

- **linearity, gain error, offset error**

Linearity, gain error, and offset error are factors that combine to affect amplifier accuracy. To simplify performance predictions, AstroDAQ signal conditioner descriptions combine these factors into a single specification referred to as Total Error (25° C). The Total Error specification describes the maximum error introduced by the amplifier when a reference is measured at an ambient temperature of 25° C. Because ambient temperature can often be controlled, its effect is specified separately.

- **bandwidth**

Bandwidth indicates the range of frequencies that can be used with an amplifier. In the case of an AstroDAQ signal conditioner, bandwidth is a total specification that includes the effect of sampling on the signal. Many other systems list only the bandwidth of the analog voltage amplifier, leaving the effect of sampling on the signal to be deduced. The result is usually a lower effective bandwidth.

- **thermal stability**

Thermal stability is baseline change with temperature.

Grounding

A ground is generally thought of as an equipotential point or structure designed so that the voltage between any two points is zero. In practice, there are no perfect grounds and all should be suspect.

Grounds may be used to: 1) provide a safe return for excess current under fault conditions; 2) shield components from external sources; or 3) provide a reference for voltage measurements. Poor grounding is a common cause of measurement error.

A review of one of the many texts on the subject of grounding is advised. The definitions below are used in this document.

- **Earth Ground**

Earth Ground is a low-impedance path to earth. In a properly installed 120-VAC outlet, the green wire is assumed to be Earth Ground.

- **Case Ground**

Case Ground refers to grounding achieved using an instrument's metal enclosure or frame. When the instrument is powered by line voltage, Case Ground is usually connected to Earth Ground for safety reasons.

- **Signal Common**

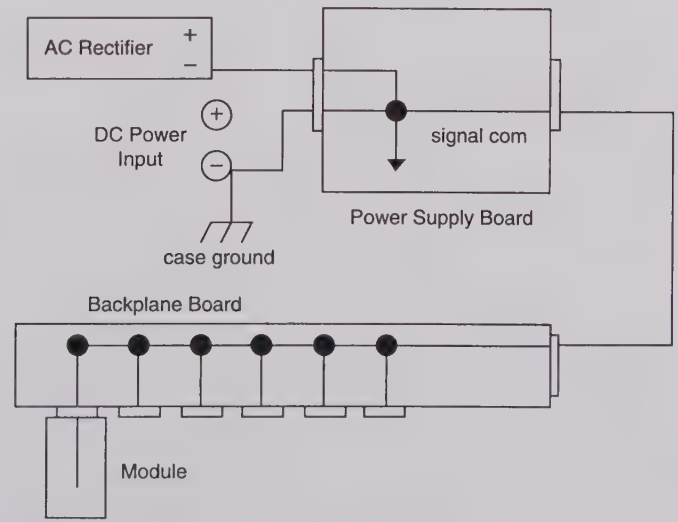
Signal Common is the analog reference point for the measuring device. In most cases, Signal Common is referenced to the instruments power supply.

- **Source Common**

Source Common is a reference point at the voltage source.

AstroDAQ enclosure grounding

The diagram below illustrates the principal ground paths within the AstroDAQ enclosure. Note that signal common is connected to the enclosure, which, in turn, is connected to Earth Ground when AC power is used.

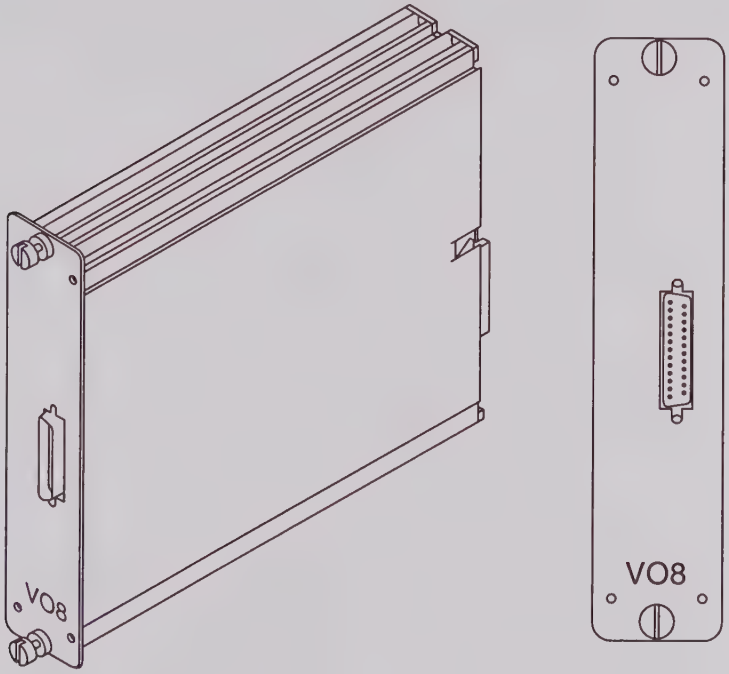


PART II

MODULE DESCRIPTIONS

5 V08 AND V08H DIFFERENTIAL VOLTAGE INPUT MODULE

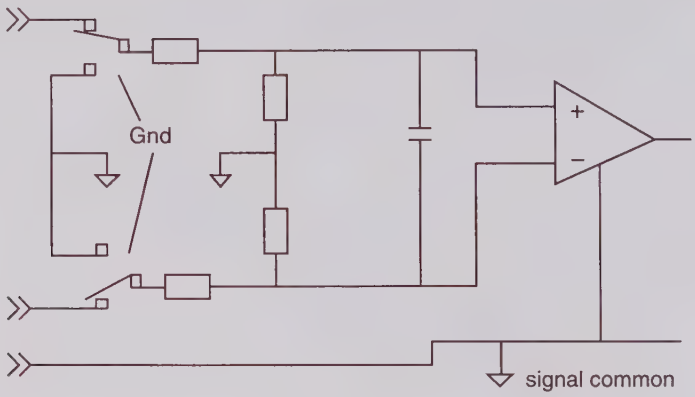
Each V08 signal conditioner module can support a maximum of eight differential voltage inputs. A maximum of six V08 modules can be used in a single AstroDAQ enclosure.



Each V08 module includes a single 16-bit analog-to-digital converter (ADC) and an 8-channel multiplexer. The active range for each channel can be independently adjusted using AstroLINK software. Each input can be independently shorted and simultaneously disconnected from the source using AstroLINK menus.

The V08H signal conditioner module is an eight-channel, differential, milli-volt version of the V08 general-purpose voltage input module. The input range of the V08H is suitable for many shunt measurements that do not require isolation. The V08H is a cost-effective solution for strain-gauge applications in which the user supplies excitation and external balance.

The input stage of a V08 channel is shown in the illustration below.



Channel specifications

V08

module units	volts
bandwidth (-3 dB)	600 Hz
input range	-20 V to +20 V
resolution	0.8 mV
maximum CMV	40 V
CMR at 60 Hz	> 90 dB*
input impedance	> 1 megohm balanced to common
thermal stability	< 0.2 mV per degree C
maximum error (25° C)	2.5 mV + .25% of measurement
maximum intrinsic noise	< 2.5 mV pk-pk (with 250 Hz filter)

V08H

module units	millivolts
bandwidth (-3 dB)	150 Hz
input range	-2 V to +2 V
resolution	0.1 mV
maximum CMV	10 V
CMR at 60 Hz	> 90dB
input impedance	> 1 megohm balanced to common
thermal stability	< 0.1 mV per degree C
maximum error (25° C)	0.5 mV + .25% of measurement
maximum intrinsic noise	< 0.5 mV pk-pk (with 250 Hz filter)

*CMR specification applies to modules with properly adjusted balance potentiometer.

V08 input connector

Pin descriptions for the V08's 25-pin D-shell input are given below.

signal	pin number	signal	pin number
Ch 1 +	1	Ch 5 +	13
Ch 1 -	2	Ch 5 -	14
Ch 2 +	4	Ch 6 +	16
Ch 2 -	5	Ch 6 -	17
Ch 3 +	7	Ch 7 +	19
Ch 3 -	8	Ch 7 -	20
Ch 4 +	10	Ch 8 +	22
Ch 4 -	11	Ch 8 -	23

Signal Common is connected to pins: 3, 6, 9, 12, 15, 18, 21, 24

DSP functions

The input waveform can be processed by any one of the following:

- adjustable low-pass filter to 500 Hz
- adjustable high-pass filter from 0.1 Hz
- adjustable band-pass filter
- adjustable band-stop filter (Notch)
- Root Mean Square (RMS) response times (0-90%) of 0.02, 0.2, and 2.0 seconds
- integrator
- differentiator with low-pass filter

Menu limits

The V08 and V08H have the following menu limits.

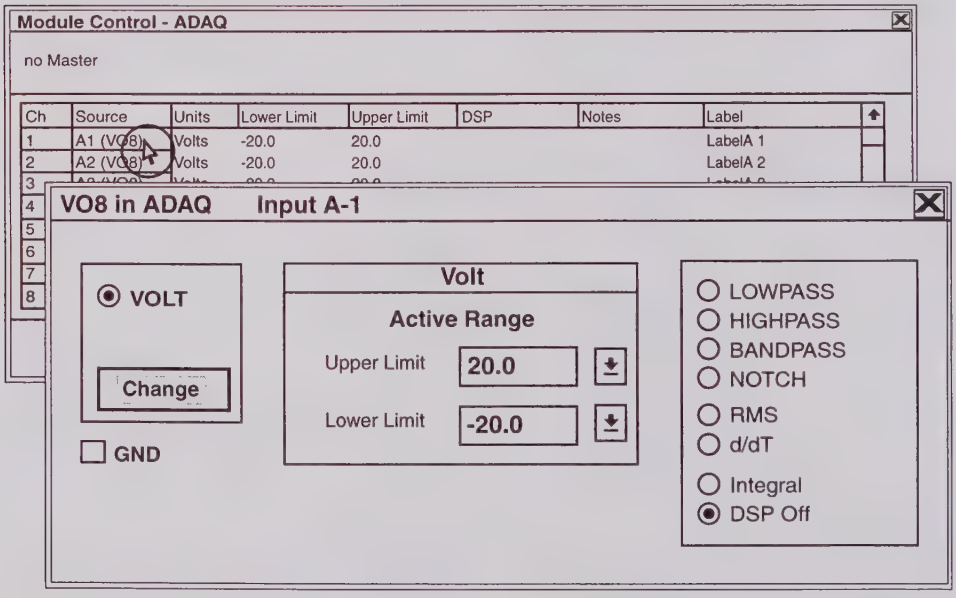
	standard V08	V08H
• maximum span	40.0 V	4.0 V
• minimum span	0.1 V	10 mV
• span step	.01 V	1 mV
• minimum lower limit	-20.0 V	-2.0 V
• maximum upper limit	20.0 V	2.0 V

V08 parameter-adjustment window

The V08 parameter-adjustment window is used to define the following V08 operating parameters:

- selecting a channel for adjustment
- grounding the input, if desired
- defining the signal voltage as user engineering units
- defining the upper and lower limits of the active input range
- enabling any of the following filters: low pass, high pass, band pass, or notch
- enabling RMS operation

The V08 parameter-adjustment window is accessed by clicking any V08 channel listed in the Module Control window. An example of the V08 parameter-adjustment window is shown below.



V08 technical notes

The sections that follow provide supplementary technical information regarding the V08 module.

V08 calibration

Calibration of V08 channels is performed using the AstroLINK service utility. Channels can be calibrated simultaneously or individually. Offset correction is the first phase of calibration. When performing offset correction, two choices for establishing a zero-volt reference are available. The AstroDAQ can short the channel inputs internally to provide a true zero reference. Alternatively, an external zero-volt reference can be applied. Externally applied zero-volt references must not deviate from true zero by more than 0.5 volts or calibration may fail. In many instances, offset correction is the only calibration that is required.

Gain correction is the second step of the calibration process. Gain correction requires the application of an external reference voltage. At the factory, Astro-Med uses voltage references which are traceable to NIST. If an appropriate voltage reference is not available for the calibration process, the V08 module should be returned to Astro-Med for calibration. The reference must be a stable DC voltage with a value specified by the calibration utility. The V08 generates any required correction factors. The correction factors are saved in the module's local nonvolatile memory.

Differential voltage measurements

All voltage measurements are made between two points. If one of these points is signal common, the measurement is said to be single-ended. When applied to amplifier design, this terminology is very clear. However, in the context of a measurement system, the terminology can be very misleading.

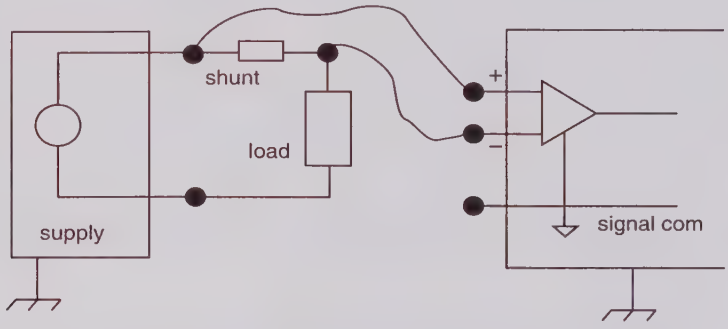
- A single-ended amplifier acts on the voltage between a single input terminal and signal common (power supply return).
- A differential amplifier acts on the difference between a pair of input terminals. The terminals are referred to as "+" and "-".

It is significant that the differential amplifier sees two signals that are each referenced to signal common. In theory, subtracting one signal from the other eliminates components of the signal that are common to both inputs. The common components would include noise that is picked up equally by both inputs.
In reality, no differential amplifier exhibits perfect performance. As a result, additional specifications are needed to judge the effectiveness of a differential amplifier.

- **Common Mode Voltage (CMV)**

Common mode voltage is defined as a signal that appears at both input terminals simultaneously with respect to signal common. When using a differential amplifier, it is important to distinguish between CMV and an input signal that refers to the voltage between positive (+) and negative (-) terminals.

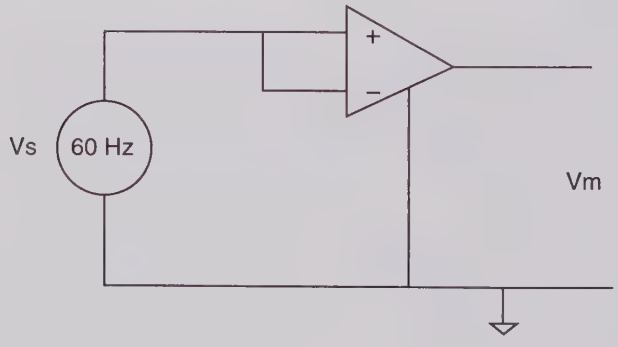
Providing that the maximum CMV of the amplifier is not exceeded, differential amplifiers can be used for 'off ground' measurements.



Differential amplifiers such as the V08 can be effective in reducing noise picked up by signal leads. For example, the amplifier could reduce the noise caused when the wires connecting the source to the measuring device pass a 60-Hz source. Only noise common to both inputs is rejected.

- **Common Mode Rejection (CMR)**

The common mode rejection specification indicates the degree to which the common signal is reduced. Given in decibels, CMR is usually specified for a 60-Hz sinusoid. Lower frequencies and DC levels have larger CMRs. The figure below illustrates how CMR is measured. If the amplitude of Vs is 1 volt and the amplifier CMR is 90 dB, the amplitude of Vm will be approximately 31 micro-volts.



Good common mode rejection can be achieved only if the positive and negative inputs see the same impedance. V08 modules include a balance potentiometer, which is used to compensate for any differences in the input paths. To adjust this potentiometer, apply a 60-Hz source as shown in the preceeding figure. Make sure the peak voltage does not exceed the V08 input range. Use the AstroLINK Monitor to measure the resultant signal and adjust the balance to minimize the 60-Hz component.

Some early versions of V08 may not include a balance potentiometer. In such cases, CMR will be lower. Nominal values without the potentiometer are 55 dB. V08H does not require a balance potentiometer.

Current output transducers

The V08 can be used to measure a current source by placing a resistor in parallel with the voltage inputs. Astro-Med provides a V08 option for 4 mA and 20 mA transducers.

Resistance temperature detector (RTD)

Resistance temperature detector (RTD) technology exploits the fact that the resistivity of metals changes with temperature. Historically, platinum wire was used in RTD sensors because of its stability at high temperatures. In current technology, an RTD is more likely to be made from a metal film deposited onto a ceramic substrate. Although all metals exhibit resistivity change with temperature, platinum remains the metal of choice for RTDs. In cases where cost is a more significant factor than performance, copper nickel alloys are often used.

Although very accurate and stable, some RTDs are more fragile than thermocouple sensors and must be handled properly. Depending on the construction of the RTD device, the sensor can be used to monitor temperatures between -250° to 800° C. The most common resistance of an RTD is 100 ohms, and resistance change is about 0.4 ohms per degree Celsius. The most significant measurement errors in RTD sensors are the result of self-heating and thermal electromotive force (EMF) at the platinum to copper junction.

The table below gives resistance values in ohms for the two standard types of platinum RTDs.

	-100° C	0° C	100° C	200° C	300° C
Euro - (.00385)	60.25	100	138.5	175.84	212.02
Amer - (.00392)	59.57	100	139.16	177.13	213.93

All RTDs have at least two wires (red and black); some may have three or four wires. A three-wire RTD usually has two black wires, while a four-wire RTD can have two black and two red. If this is not your RTD configuration, contact your RTD manufacturer.

Contact Astro-Med Technical Support to obtain an adapter for using the RTDs with the V08.

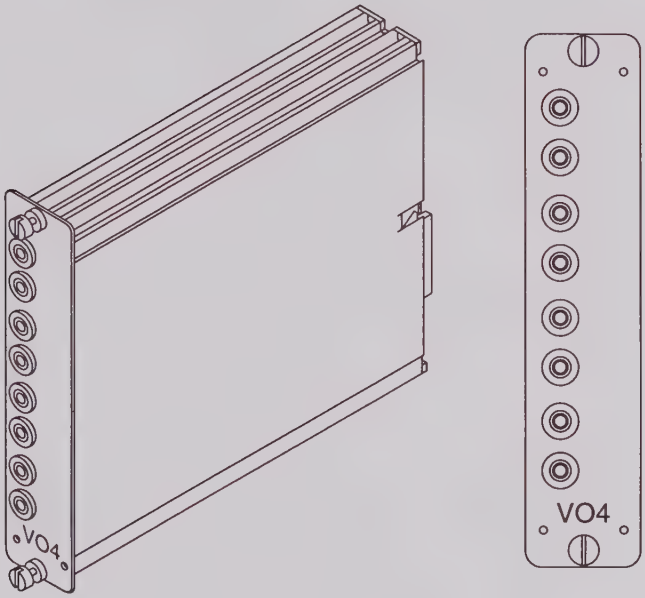
V08 options

V0 8 options include:

1. BNC Input Adaptor
2. 4 - 20 mA converter

6 V04 ISOLATED VOLTAGE INPUT MODULE

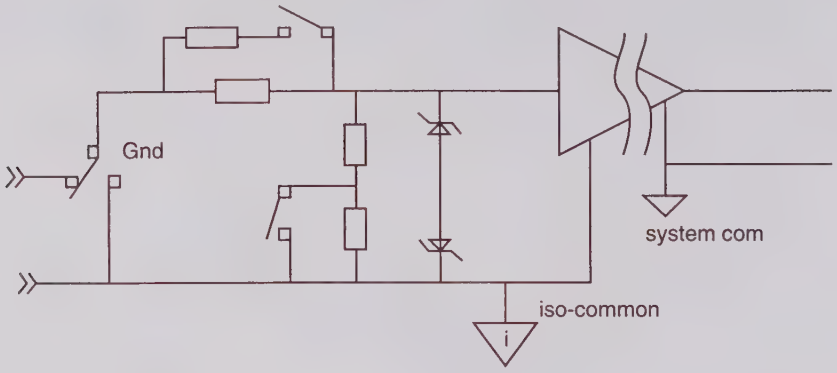
Each V04 signal conditioner module can support a maximum of four isolated voltage inputs. A maximum of six V04 modules can be used in a single AstroDAQ enclosure.



Each V04 signal conditioner module includes a single 16-bit ADC and a 4-channel multiplexer. For each channel there are two input ranges. Depending on the sensitivity of the measurement, the input ranges for each can be selected independently. The active range for each channel can be independently adjusted using AstroLINK software.

Each input can be independently shorted and simultaneously disconnected from the source using the Gnd selection in AstroLINK menus.

The input stage of a V04 channel is shown in the diagram below.



V04 channel specifications

	standard mode (A)	high voltage mode (B)
module units	volts	volts
bandwidth (-3dB)	1 KHz	1 KHz
measurement range	-6 V to 6 V	-400 V to 400 V
UL-rated input	---	250 V RMS
resolution	0.25 mV	0.02 V
maximum IMV	500 V	500 V
IMR at 60 Hz	>100 dB	>100 dB
NMR at 60Hz	> 90 dB	> 55 dB
input impedance	1.0 megohm	1.0 megohm
thermal stability	< 0.1 mV per degree C	< 2 mV per degree C
maximum error (25° C)	2.0 mV + .2% of measurement	0.05 V + .2% of measurement
maximum intrinsic noise	< 2 mV pk-pk (filters off)	< 0.05 V pk-pk (250 Hz filter)

V04 input connectors

The V04 signal conditioner module uses guarded banana jack inputs. The red input is the signal. The black input is iso-common.

DSP functions

The input waveform can be processed by any one of the following:

- adjustable low-pass filter to 500 Hz
- adjustable high-pass filter from 0.1 Hz
- adjustable band-pass filter
- adjustable band-stop filter (Notch)
- root mean square (RMS) response times (0-90%) of 0.02, 0.2, and 2.0 seconds
- integrator
- differentiator with low-pass filter

V04 menu limits

The V04 has the following menu limits:

Mode A

• maximum span	12.0 V
• minimum span	.05 V
• span step	.01 V
• minimum lower limit	-6.0 V
• maximum upper limit	6.0 V

Mode B

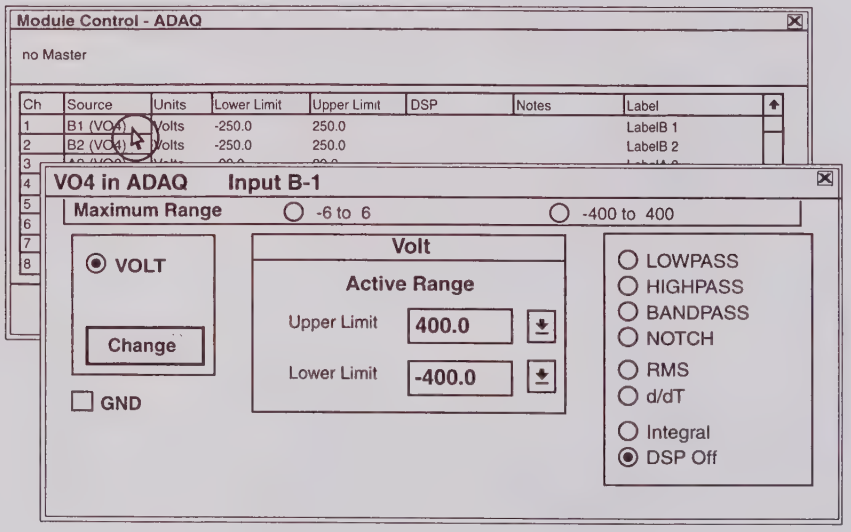
• maximum span	800.0 V
• minimum span	4.0 V
• span step	.5 V
• minimum lower limit	-400 V
• maximum upper limit	400 V

V04 parameter-adjustment window

The V04 parameter-adjustment window is used to define the following V04 operating parameters:

- selecting a channel for adjustment
- grounding the input, if desired
- defining the signal voltage as user-specified engineering units
- defining the upper and lower limits of the active input range
- enabling any of the following filters: low-pass, high-pass, band-pass, or notch
- enabling RMS operation

The V04 parameter-adjustment window is accessed by clicking any V04 channel listed in the Module Control window. An example of the V04 parameter-adjustment window is shown below.



V04 technical notes

The remaining pages of this chapter provide supplementary technical information regarding the V04 module and isolation amplifiers in general.

V04 calibration

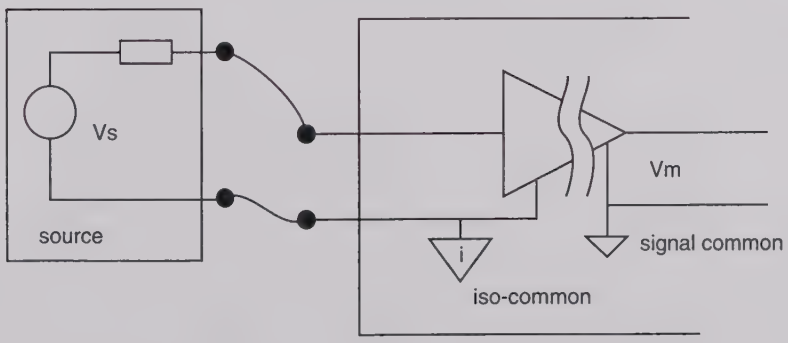
Calibration of V04 channels is performed using the AstroLINK service utility. Channels can be calibrated simultaneously or individually. Separate correction factors are maintained for each of the two gain modes.

Offset correction is the first step of the calibration process. When performing offset correction, two choices for establishing a zero-volt reference are available: 1) the AstroDAQ can short the channel inputs internally to provide a true zero reference, *or*; 2) an external zero-volt reference can be applied. Calibration may fail if externally applied zero-volt references deviate from true zero by more than 0.3 volts in mode A or 5 volts in mode B. *In many instances, offset correction is the only calibration that is required.*

Gain correction is the second step of the calibration process. Gain correction requires the application of an external reference voltage. At the factory, Astro-Med uses voltage references which are traceable to NIST. If an appropriate voltage reference is not available for the calibration process, the V04 module should be returned to Astro-Med for calibration. The reference must be a stable DC voltage with a value specified by the calibration utility. After the source is applied, the V04 generates any required correction factors. The correction factors are saved in the module's own nonvolatile memory.

Isolation amplifiers

An isolation amplifier is an amplifier that can function without making an electrical connection between the source common and the signal common of the measurement system. This capability increases safety, allows 'off ground' measurements at much higher potentials, and, in some cases, reduces noise pickup. In this document, the signal reference used by the isolation amplifier is referred to as iso-common, as distinguished from the AstroDAQ's signal common (shown below).



In some cases, a single iso-common is shared by all isolated channels. In these cases, the channels are not isolated from one another. The AstroDAQ System's V04 signal conditioner module provides four truly isolated channels. Each V04 channel has a separate iso-common.

In the V04 module, isolation is provided by a physical gap inside an isolation module. The incoming signal is modulated and transformer-coupled across the gap.

Although it is possible to have an input that is both differential and isolated, most general-purpose isolated inputs are single-ended, as shown on the previous page. An isolated, single-ended input has characteristics similar to a non-isolated differential input, but with a much higher common mode voltage (CMV) capability. In discussing isolated amplifiers, the term isolation mode voltage (IMV) is often used interchangeably with CMV.

Isolation mode rejection (IMR) indicates the effectiveness of isolation. It specifies the output signal that results from applying a voltage between iso-common and case ground. It is given in decibels (dB). Normal mode rejection (NMR) specifies the output signal that results from applying a voltage between signal input and iso-common. It is also given in dB.

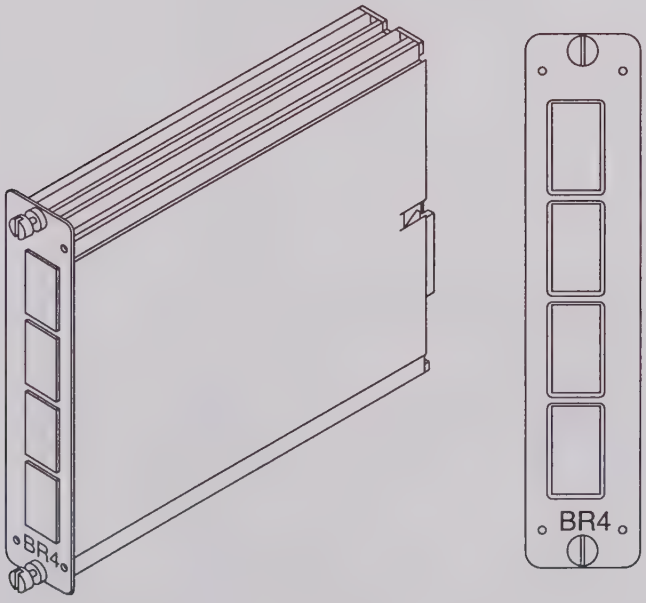
7 BR4 BRIDGE MODULE

The AstroDAQ BR4 signal conditioner module supports a maximum of four independent DC bridge circuits using voltage excitation. A maximum of six BR4 modules can be installed in a single AstroDAQ enclosure. Each module includes a single 16-bit ADC, a 4-channel multiplexer, and a DSP. Two input ranges are available in the BR4 and active ranges for each channel are independently adjustable. Control is provided through AstroLINK menus.

All BR4 and BR4H inputs are electrically isolated from chassis ground and other inputs.

Measurements can be made in either mV/V or micro-strain (με). Both measurement types automatically include the setting for excitation voltage. When conversion factors are available, outputs can also be converted to user-specified units such as pounds or psi.

- The BR4H is a version of the BR4 which is optimized for more sensitive measurements. It is ideal for use with load cells and transducers rated at 1, 2 or 3 mV/V.
- The BR4A signal conditioner module is identical to the BR4 except for its input connectors.

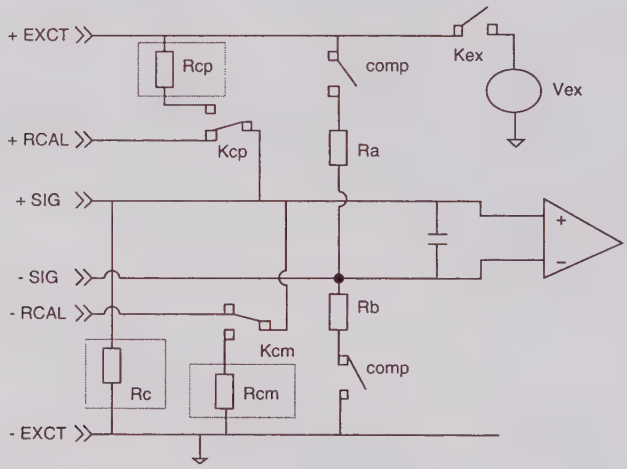


BR4 input stage

The input stage of a BR4 and BR4H channel is illustrated below. The value of Vex is selectable (5 V or 10 V) using AstroLINK software. The resistors **Rc**, **Rcp**, and **Rcm** are socketed and can be modified by the user.

A switch labeled comp (one per channel) is located near the input connector on the circuit board. The switch is used to connect bridge completion resistors **Ra** and **Rb** to the measurement circuit. **Ra** and **Rb** each have a value of 352 ohms.

In the diagram, Kcp, Kcm, and Kex are relays controlled using AstroLINK software.



Board-mounted switches

Each channel is associated with a switch for connecting completion resistors. Each switch is labeled. The label for channel 1 is S1. The label for channel 2 is S2. The label for channel 3 is S3. The label for channel 4 is S4.

Channel specifications

The specifications provided here are generic and are independent of the measurement type. The specific limits of each measurement type are given elsewhere. "Mode" applies to the hardware gain of a channel. Unless otherwise indicated, specifications apply to 10 V excitation.

BR4 & BR4A	high sensitivity mode (A)	standard mode (B)
bandwidth (-3 dB)	500 Hz	500 Hz
auto balance range	± 0.25 V	± 0.25 V
resolution	0.1 mV	0.1 mV
maximum differential input	500 mV	500 mV
maximum CMV	± 5 V	± 5 V
maximum IMV	250 V	250 V
IMR at 60 Hz	> 90 dB	> 90 dB
excitation	5 V or 10 V	5 V or 10 V
max excitation current	50 mA	50 mA
input impedance	10 megohm	10 megohm
thermal stability	< 25 µV per degree C	< 25 µV per degree C
maximum error (25° C)	0.5 mV + .2% of measurement	1 mV + .2% of measurement
maximum intrinsic noise	< 500 µV pk-pk, measured with 250 Hz filter and 10 V excitation	< 500 µV pk-pk, measured with 250 Hz filter and 10 V excitation

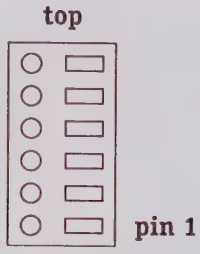
BR4H	high sensitivity mode (A)	standard mode (B)
bandwidth (-3 dB)	500 Hz	500 Hz
auto balance range	± 10 mV	± 20 mV
resolution	.01 mV	.01 mV
maximum CMV	± 5 V	± 5 V
maximum IMV	250 V	250 V
IMR at 60 Hz	> 90 dB	> 90 dB
excitation	5 V or 10 V	5 V or 10 V
maximum excitation current	50 mA	50 mA
input impedance	10 megohm	10 megohm
thermal stability	< 10 µV / degree C	20 µV / degree C
maximum error (25° C)	.025 mV	.05 mV
maximum intrinsic noise	< 50 µV pk-pk, measured with 100 Hz filter and 10 V excitation	< 50 µV pk-pk, measured with 100 Hz filter and 10 V excitation

Input connectors

Pin descriptions for the BR4's input connector are given below.

signal	pin number*
SIG +	3
SIG -	4
EXCT +	1
EXCT -	5
RCAL +	2
RCAL -	6

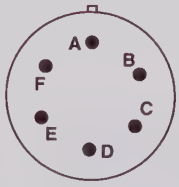
*When a channel is not in use, jump pin 3 to 4.



The BR4A and BR4H input connector pin connections are given below.

signal	pin number*
EXCT +	A
SIGNAL +	B
SIGNAL -	C
EXCT -	D
RCALEXT +	E
RCALEXT -	F

*When a channel is not in use, jump pin B to C.



BR4A and BR4H connector wiring-side view

DSP functions

The generic DSP functions available for all measurement types are listed below.

adjustable band start:	0.1 to 25 Hz
adjustable band stop:	5 to 250 Hz
adjustable bandpass	
other DSP functions:	50/60 notch

Menu limits using the mV/V measurement type

The lower and upper menu limits listed below take into account the selected excitation voltage and mode.

	BR4 & BR4A		BR4H	
	Mode A	Mode B	Mode A	Mode B
• maximum span	50 mV/V	100 mV/V	5 mV/V	10 mV/V
• minimum span	1 mV/V	2 mV/V	0.1 mV/V	0.2 mV/V
• span step	0.1 mV/V	0.1 mV/V	0.01 mV/V	0.01 mV/V
• minimum lower limit	-50 mV/V	-100 mV/V	-5 mV/V	-10 mV/V
• maximum upper limit	50 mV/V	100 mV/V	+5 mV/V	+10 mV/V

Using the mV/V measurement type

When the mV/V measurement type is chosen, measurements are expressed in mV/V. If the use of special engineering units has been selected, the mV/V values of the measurements will be converted into the specified engineering units. Many transducers, including most load cells, have outputs calibrated in mV/V.

Menu limits using the micro-strain (με) measurement type

	BR4 & BR4A		BR4H	
	Mode A	Mode B	Mode A	Mode B
• maximum span	100000 με	200000 με	10000 με	20000 με
• minimum span	2000 με	4000 με	200 με	400 με
• span step	200 με	200 με	20 με	20 με
• minimum lower limit	-100000 με	-200000 με	-10000 με	-20000 με
• maximum upper limit	100000 με	200000 με	10000 με	20000 με

BR4 parameter-adjustment window

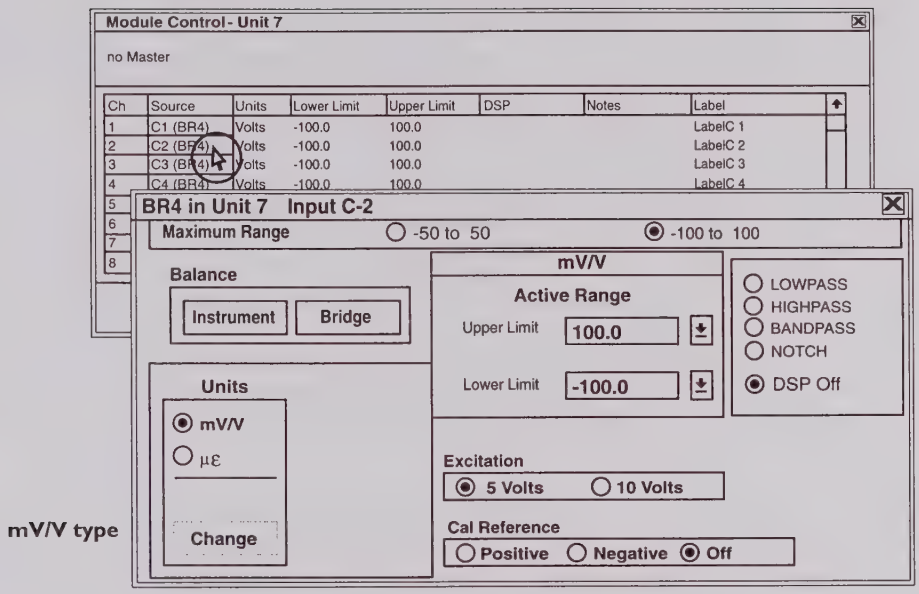
The BR4 parameter-adjustment windows are used to define the following BR4 operating parameters:

- selecting a channel for adjustment
- selecting a filter
- selecting a bridge type, gauge factor (με only)
- selecting the mV/V or με measurement type
- defining the upper and lower limits of the transducer sensitivity
- defining the instrument sensitivity settings
- setting the excitation level

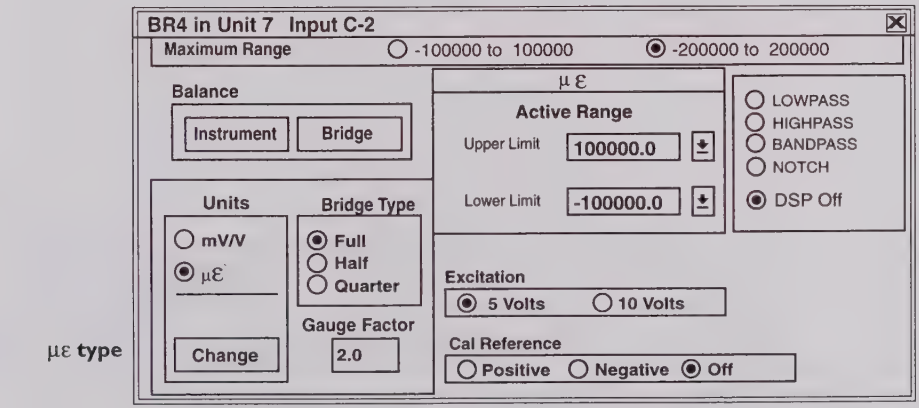
To access the BR4 parameter-adjustment window, click any BR4 channel listed in the Module Control window. The windows for the mV/V measurement type and the microstrain measurement type vary slightly. Examples of the BR4 parameter-adjustment windows are shown on the next page.

BR4 technical notes

The following pages of this section provide supplementary technical information regarding the BR4 module and bridge amplifiers in general.



mV/V type



με type

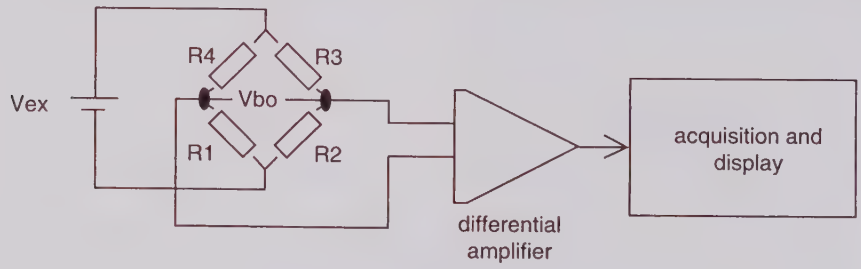
Basic DC bridge

The basic bridge circuit is referred to as the Wheatstone Bridge. For resistance measurements, the Wheatstone bridge consists of:

- 4 resistors connected to form a quadrilateral
- a source of excitation (voltage or current) connected along one of the diagonals
- a voltage-measuring device connected across the other diagonal

Essentially, the measuring device senses the difference between two voltage dividers connected across the excitation supply.

The figure below shows the common Wheatstone bridge driven by voltage excitation.



The general equation for the bridge output voltage (Vbo) is:

$$Vbo = Vex [(R1 / (R1 + R4)) - (R2 / (R2 + R3))]$$

The bridge is said to be balanced or nulled when Vbo = 0. This is achieved when R1/R4 = R2/R3. Traditionally, bridge measurements involve adjusting one of the bridge arms until the bridge is balanced. The physical parameter under measurement is then allowed to alter the resistance of one of the other bridge arms. This causes an imbalance and a resultant change in Vbo. To eliminate the delicate adjustments associated with balancing the bridge, the BR4 is designed to make measurements with an unbalanced bridge.

Basic calibration

Calibration begins with calibrating each channel as a voltage amplifier. Calibration is performed using an AstroLINK software utility. Channels can be calibrated simultaneously or individually.

Offset correction is the first step of the calibration process. An external zero-volt reference must be applied. Calibration may fail if externally applied zero-volt references deviate significantly.

Gain correction is the second step of the calibration process. Gain correction requires the application of an external reference voltage. At the factory, Astro-Med uses voltage references which are traceable to NIST. If an appropriate voltage reference is not available for the calibration process, the BR4 module should be returned to Astro-Med for calibration. The reference must be a stable DC voltage with a value of 50 millivolts. After the source is specified, the BR4 generates any required correction factors. The factors are saved in the module's own nonvolatile memory.

It is not possible to adjust the BR4 excitation source. To ensure the smallest possible measurement error, further calibration steps should include the transducer and any associated wiring.

Secondary calibration feature

AstroLINK software provides a special feature which allows for secondary calibration of any transducer attached to the BR4 bridge module. This adjustment is a gain correction factor and is performed after basic calibration of the BR4 bridge module has been completed as described in the previous paragraph.

Secondary calibration is performed in user engineering units for a more exact calibration measurement.

To perform secondary calibration of the transducer:

1 Attach the transducer to be calibrated to the BR4 bridge module.

2 Click the Monitor icon to open the Monitor window.

- Set the "Mode" format to Meter Mode; keep the Meter Mode window open.

3 Click the Module Control icon to open the Module Control window.

- Use the Change button to specify the user engineering units. (See "Specifying user engineering units" in chapter 4 for further information on specifying units appropriate to the module.)

- Click the unit label of the specified BR4 unit to access the BR4 parameter-adjustment window. Make selections as appropriate.

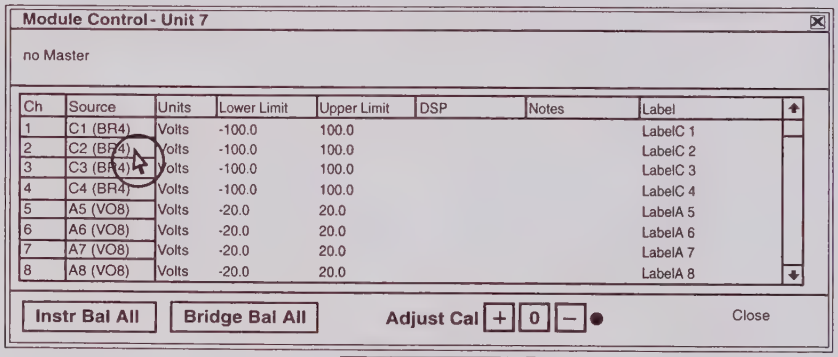
4 Balance the transducer as described on the next page.

5 Attach a load with a known input to the transducer.

6 Using the "Adjust Cal" controls (shown below), make calibration adjustments.

NOTE

Because the Adjust Cal control permits a very fine adjustment of the calibration, it may appear that the increase or decrease command is not being accepted. Continue to click the "+" or "-" button and view the monitor meter screen to note the progress of the calibration.

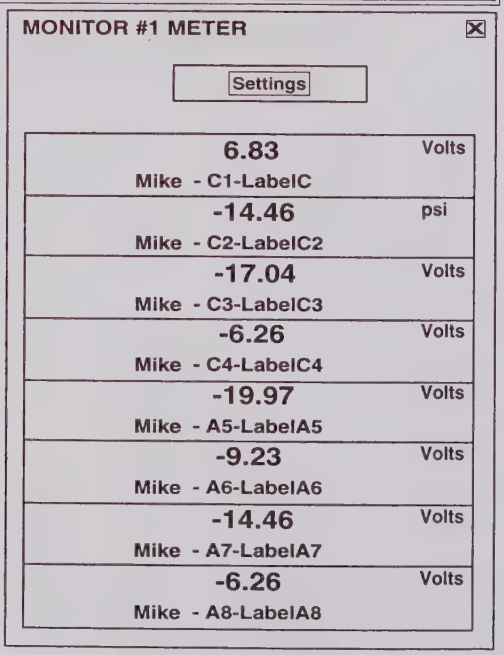

Module Control - Unit 7
no Master
Ch Source Units Lower Limit Upper Limit DSP Notes Label
1 C1 (BR4) Volts -100.0 100.0 LabelC 1
2 C2 (BR4) Volts -100.0 100.0 LabelC 2
3 C3 (BR4) Volts -100.0 100.0 LabelC 3
4 C4 (BR4) Volts -100.0 100.0 LabelC 4
5 A5 (VO8) Volts -20.0 20.0 LabelA 5
6 A6 (VO8) Volts -20.0 20.0 LabelA 6
7 A7 (VO8) Volts -20.0 20.0 LabelA 7
8 A8 (VO8) Volts -20.0 20.0 LabelA 8
Instr Bal All
Bridge Bal All
Adjust Cal + 0 −
Close

The "Adjust Cal" buttons modify channel gain calibration. Click the "+" and "-" buttons to provide a fine adjustment of the gain correction factor within a range from .5 to 2, with the "0" button representing 1 or 100%.

The change is saved by the module until a service calibration is performed, returning the factor to 1.

Clicking "0" will return the value to the last service calibration.

The yellow indicator is lit when the gain correction factor is active (not set to 1).



About the auto-balance (nulling) functions

The term balance refers to the process of correcting the signal output for the effects of bridge imbalance. This is done mathematically by the module DSP while the input represents a resting or zero state. During the balance process, the DSP monitors the signal and computes an average deviation from the zero. This is then saved and used to correct all future inputs. Each channel has a unique correction factor.

The BR4 module provides two methods for balance.

- Instrument balance

This method causes the excitation voltage to be disconnected from the transducer before the actual balance process begins. This can be useful in situations where it is not practical to unload the transducer.

- Bridge balance

This method assumes that the user has put the transducer in an unloaded or zero state. The only difference between this and instrument balance is excitation.

Either balance method can be used on any channel through the parameter adjustment menu. Alternatively, all channels can be balanced at once using a single button in the Master section of the Module Control window.

Calibration resistors

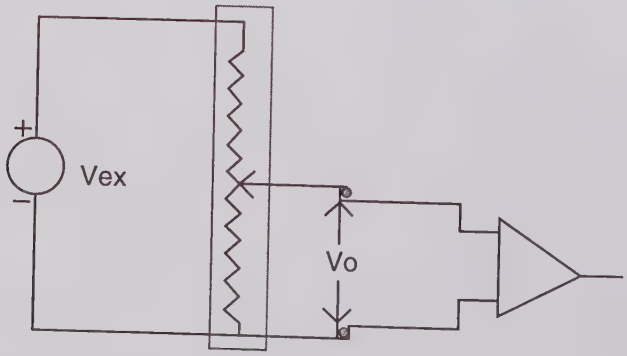
BR4 modules have sockets for both positive and negative calibration resistors. When the transducer is some distance from the amplifier and leadwire errors are unacceptable, external calibration resistors can be used with BR4 modules. The Make Test utility is used to specify whether an internal or external resistor is being used. When performing a test, this parameter should not be changed.

The AstroLINK Module Control window provides a one-click control that simultaneously activates the calibration resistors for all BR4 channels installed in an AstroDAQ enclosure. Channels of the BR4 module can also be individually activated. In either case, calibration is not actually performed. Instead, transducer calibration is verified by creating a known signal change.

Irrespective of the location of the resistor, the effect on the signal is created by connecting the resistor across one arm of the bridge. As shown in the circuit diagram provided earlier, **Rcp** is switched across the arm from +EXCT to +SIG. **Rcm** would be switched across -EXCT to +SIG. These arrangements simulate either positive or negative gauge changes. If an external **Rcp** is used, the BR4 connection +RCAL should be connected to one end of the resistor at the transducer. The other end should be connected to +EXCT at the transducer. If an external **Rcm** is used, the BR4 connection -RCAL should be connected to one end of the resistor at the transducer. The other end should be connected to -EXCT at the transducer. Activating the calibration resistor reduces the resistance in the selected bridge arm.

Potentiometric transducers

The diagram of a potentiometer circuit shown below consists of a constant voltage source (Vex) connected to the ends of a resistor. The resistor has a movable slider contacting the resistance element. The voltage source is referred to as the excitation voltage. The output voltage (Vo) is measured between the slider and one of the other terminals.



This type of potentiometer transducer is most useful for measuring relatively large linear displacements. Most potentiometers use wire-wound resistance elements that limit resolution. Some film resistor potentiometer types are available.

The variation of output impedance with slider position is a problem with this type of potentiometer. The signal conditioning equipment must have high-input impedance to prevent loading effects. The current through the resistance element changes as a result of changes in the excitation voltage (applied voltage) or the shunting effects of low resistance in the output circuit. This results in measurement errors.

The inertia and friction present in the mechanical portion of potentiometric transducer elements result in significant restrictions when using these devices to obtain dynamic measurements. Furthermore, the sliding contact wears rapidly in continuous service, severely reducing the reliability of the transducer.

Load cells

A load cell is a transducer that converts applied weight into an electrical signal. This kind of conversion is most commonly accomplished using strain gauges bonded to a cell and connected in a bridge configuration. Some load cells include signal conditioning, but most appear as full-bridge configurations. These require DC excitation and return a voltage proportional to the applied weight and the level of excitation.

Specifications for most load cells include required excitation levels, output sensitivity in mV/V, weight, range, and resolution.

Consider the following example of a load cell:

> A load cell is rated at a capacity of 1000 lbs. and an output of 2 mV/V. At 10 V excitation, a 100 lb. load will create a voltage output of 2 mV (2 x 10 x (100 / 1000)). The accuracy of these cells is often specified at better then 0.05 % of full scale.

In practice, the accuracy of a load cell depends on a number of factors, including the cell's method of construction, environmental effects, and the way in which the load is applied.

Pressure transducers

A pressure transducer converts pressure into an electrical signal. Pressure is defined as force load per unit area. Pressure is often expressed in units that directly reflect the physical nature of the specific kind of pressure. For example, units include pounds per square inch (psi) and kilograms per square centimeter (Kg/cm^2). Pressure can also be expressed in indirect units such as the height of a column of a liquid acted on by gravitational force. Pressure expressed in this way has resulted in terms such as inches of water, inches of mercury, and millimeters of mercury (mmHg).

All pressure measurements are differential and involve either pressure between two points or pressure at a particular point with reference to a standard. The following terms are used to indicate the pressure reference:

Absolute pressure	-	pressure relative to a vacuum
Gauge pressure	-	pressure relative to local atmosphere
Sealed Gauge pressure	-	pressure relative to sea level (14.7 PSI)

Usually, pressure transducers work by detecting the deflection of a diaphragm placed between the two pressure sources. When the transducer is designed to read absolute pressure, one side of the diaphragm is sealed with a vacuum. Transducers designed to read gauge pressure have one side open to the atmosphere.

A popular type of pressure transducer senses diaphragm deflection with strain gauges arranged in a bridge configuration. This type of pressure transducer is intended for use with a DC bridge.

DC linear variable differential transducer (LVDT)

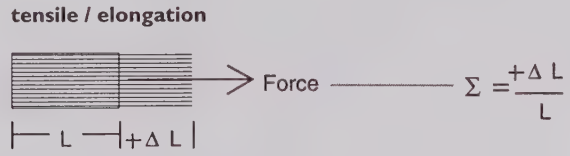
Generally, a linear variable differential transducer (LVDT) requires AC excitation not provided by the BR4. Some LVDT vendors embed excitation circuitry in the body of the transducer. Such transducers are referred to as DC LVDTs and require only the DC excitation provided by the BR4. Excitation requirements should be verified with the vendor.

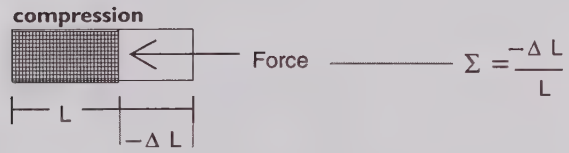
Strain gauges

Concepts associated with strain measurement include strain, stress, gauge construction, and gauge factor. Each of these is discussed below.

- **Strain**

Normal Strain is defined as a fractional change or deformation per unit length in a body resulting from an applied force. Strain is either positive or negative. Positive strain is described as tensile; negative strain is described as compressive.





The ratio of the change to the resting length is a dimensionless quantity that can be described as a percent strain. Generally, the ratio is expressed as micro strain defined in parts per million. For example:

0.001 inch/inch = 0.1% strain = 1000 micro-strain

- **Stress**

Stress is a term used to describe the relationship between the loading of a material with the material's ability to carry the load. Stress is defined as "normal stress" if the applied force is uniformly distributed over the area of a plane. Stress is defined as "shear stress" if the load is applied parallel to the plane.

Because stress cannot be measured directly, it must be evaluated using measurable parameters, such as strain, that vary in response to loading.

- **Gauge Construction**

The large resistance variation characteristic of a potentiometer contrasts sharply with the minute resistance changes characteristic of a resistance strain gauge. Types of resistance strain gauges currently used as transducer elements include the unbonded metallic-filament strain gauge, the bonded metallic foil strain gauge, and the bonded piezoresistive or semiconductor gauge.

Unbonded strain gauge elements are made of one or more filaments of resistance wire stretched between supporting insulators. The supports can be attached directly to an elastic member used as a sensing element or can be fastened independently using a rigid insulator to couple the elastic member to the filaments of the resistance wire. The displacement (strain) of the sensing element causes a change in the filament length. The change in length results in changes in resistance. Because they are fragile, transducers that use unbonded gauges are becoming less popular.

A typical foil gauge consists of a foil made from a resistance alloy, such as Constantan, bonded to an epoxy backing film. The foil is either die-cut or etched to produce a grid pattern sensitive to strain along one axis.

- **Gauge Factor (Gf)**

Gauge factor is defined as the fractional change in resistance to the fractional change in length (strain) along the axis of a strain gauge. It is a dimensionless quantity that applies to the changes in the strain gauge as a whole. Typical gauge factors are close to 2.0. Gauge factors for special strain gauges can be significantly larger or even negative. The equation for gauge factor is :

$$Gf = (\Delta R / R) / (\Delta L / L)$$

or

$$\Delta R = R \times Gf \times \text{strain}$$

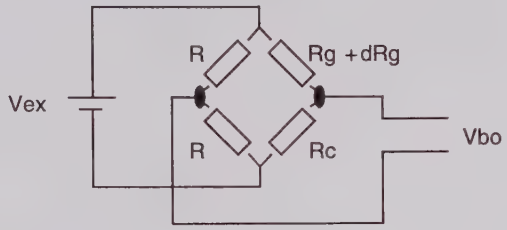
This implies that when 10 micro-strain ($\mu\varepsilon$) is applied to a gauge with R = 120 ohms and Gf = 2.0, resistance will be changed by .0024 ohms.

Generally provided by the strain gauge manufacturer, the gauge factor (Gf) specification is valid only for a specific excitation voltage and ambient temperature. As a result, Gf cannot always be used directly to calibrate a measurement.

A sensitivity factor is sometimes specified. The sensitivity factor equals the gauge factor multiplied by a correction based on current measurement conditions. If the current conditions are the same as those under which the gauge factor was specified, the sensitivity factor and the gauge factor are identical.

Quarter-bridge circuits (general description)

In quarter-bridge configurations, one of the bridge arms varies with the physical parameter to be measured and the others remain constant. A quarter-bridge circuit is shown below.



The previously presented general equation for bridge output voltage becomes:

$$Vbo / Vex = (Rc / (Rc + Rg + dRg)) - (1 / 2)$$

The bridge is said to be balanced when **Rc** is chosen to match **Rg**. **Rg** represents the resting resistance of the transducer.

For strain measurements when Rc = Rg, the definition of Gauge factor can be substituted and the equation rearranged to obtain the following:

$$Vbo / Vex = Gf / (4 + 2\ Gf)$$

Though the purpose of this equation is to describe the basic operation of the quarter bridge strain gauge, it is only an approximation. In practice, many things including temperature, the effect of connecting wire, errors in Gf, and mismatches between **Rg** and **Rc** can cause the expected output to differ from this equation.

Depending on transducer specifications, excitation voltage can be set to either 5 or 10 volts. The 50 mA per channel current limit of the BR4 module must be taken into account.

Quarter-bridge circuits (BR4-specific)

COMPLETION RESISTORS

Commercial strain gauges vary in resting resistance from 120 to 1000 ohms. The most common resting resistance value is 350 ohms. The built-in completion resistors, **Ra** and **Rb**, have resting resistance values of 352 ohms (see illustration below). This value is ideal for 350-ohm gauges and reasonable for gauge resistances from 100 to 1000 ohms.

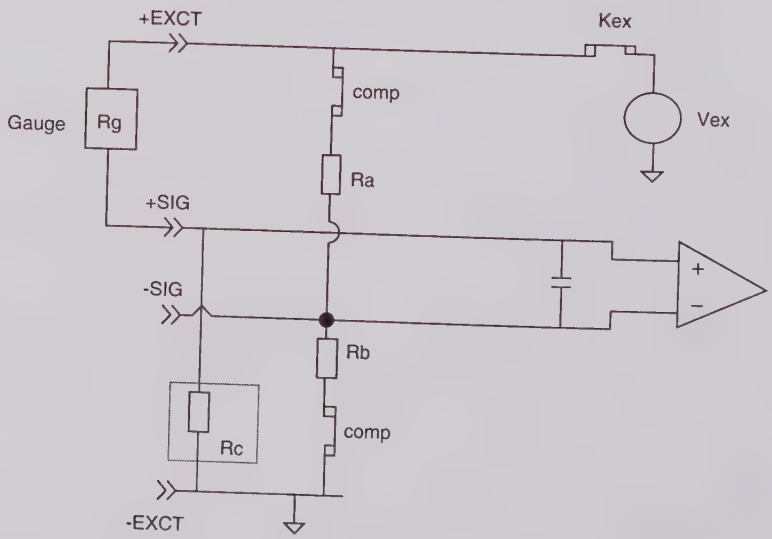
For unusual sensors, the built-in completion resistors should be switched off and external components should be supplied by the user.

A third completion resistor, **Rc**, must be user-supplied. The BR4 module has a socket for internal installation of **Rc**. To minimize bridge imbalance under no load conditions, this resistor should be as close as possible to the nominal resistance of the gauge. Inappropriate selection of this resistor may compromise the BR4 module's auto-balance capability.

PHYSICAL SETUP OF A QUARTER-BRIDGE CONFIGURATION

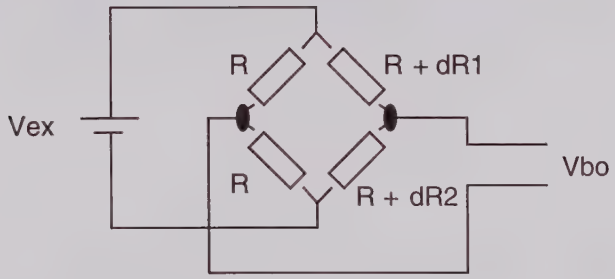
If internal bridge completion resistors are used, the bridge completion resistor switch on the module's circuit board must be set to ON. Also, an appropriate completion resistor must be installed in the socket provided. The completion resistor is labeled **Rc** in the figure below. The quarter-bridge should then be wired as shown below.

If available, a shield drain wire should be connected to -EXCT at the module side of the cable.



Other bridge arrangements

In a half-bridge configuration, one bridge arm consists of two sensors and the other bridge arm consists of two constant resistors. A half-bridge circuit is shown below.



A special case of strain measurement exists in which dR1 is equal and opposite to dR2. The approximating equation is:

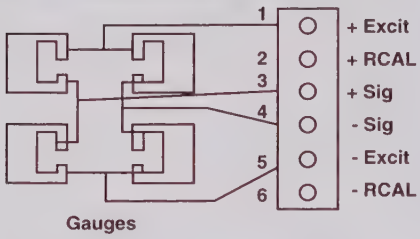
$$Vout / Vex = Gf / 2$$

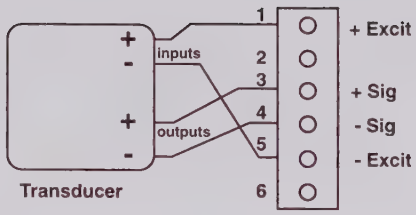
In a full-bridge configuration, all four of the bridge arms contain active elements. A variety of equations apply to full-bridge configurations, depending on the application and relationships between the active elements.

Transducer wiring

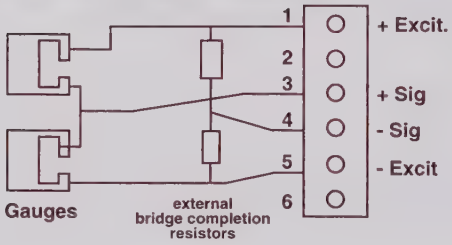
The illustrations on the next page show the transducer wiring requirements for the full-, half-, and quarter-bridge configurations of the BR4.

full-bridge configuration

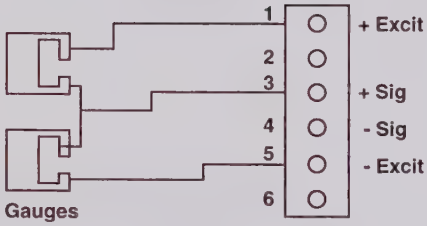




half-bridge configuration

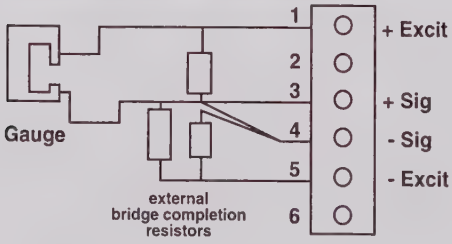


NOTE: ensure that internal bridge completion switch is set to FULL

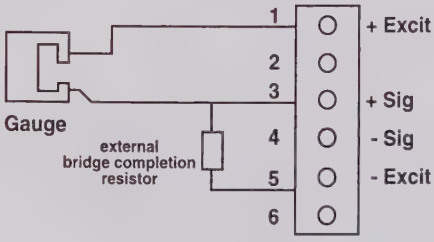


NOTE: ensure that internal bridge completion switch is set to the ON position

quarter-bridge configuration



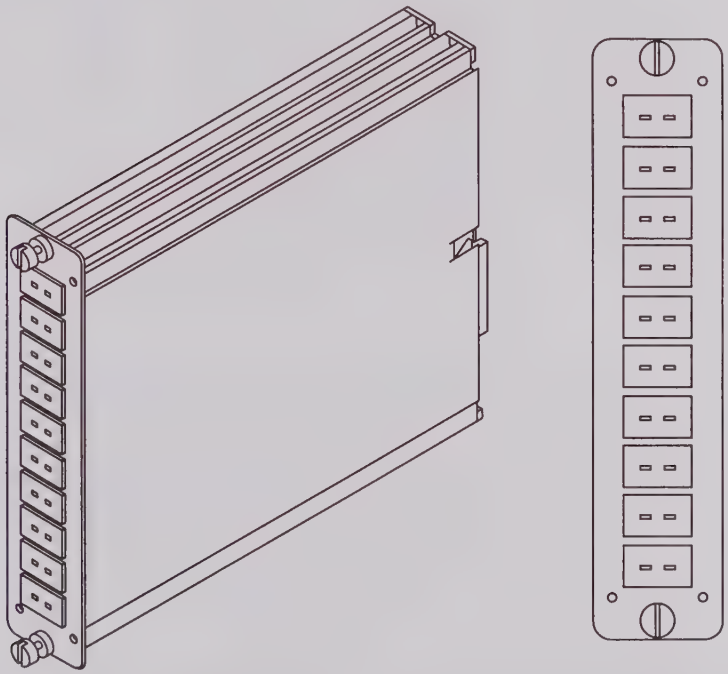
NOTE: ensure that internal bridge completion switch is set to FULL



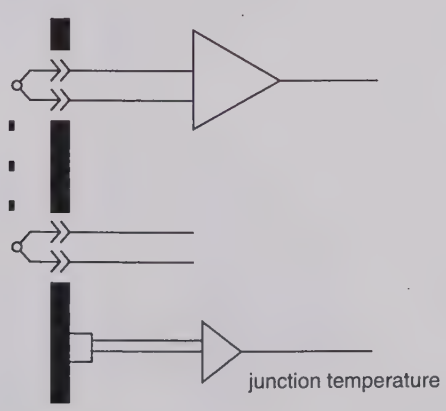
NOTE: ensure that internal bridge completion switch is set to ON position

8 TC10 THERMOCOUPLE INPUT MODULE

Each TC10 module supports a maximum of ten thermocouple inputs. A maximum of six TC10 modules can be installed in a single AstroDAQ enclosure. Each module includes one 16-bit ADC and a multiplexer. Thermocouple types J, K, E, and T are supported. In addition, the active range of each channel can be individually adjusted. AstroLINK menus are used to make parameter adjustments. The TC10 provides the means for detecting thermocouple break (e.g., open circuit).



The input stage of a TC10 thermocouple module is shown in the diagram below.



TC10 channel specifications

module units	degrees Celsius
bandwidth (-3 dB)	10 Hz
input range	20° to 650° C (J) 20° to 1200° C (K) -100° to 400° C (T) -100° to 500° C (E)
resolution	0.25° C
maximum CMV	10 V
amplifier/linearization error	0.5% of measurement + 1 degree C
junction compensation error	1° C
maximum intrinsic noise	0.5° C
cold junction compensation	yes
linearized to NIST	yes
break detect	yes

Notes:

1) Accuracy specifications are valid only within the specified ranges even though menus may permit larger measurement spans.
2) Specifications are based on performance after the unit has been powered for at least 30 minutes.
3) AstroLINK factory calibration requires traceable sources and should be done only by qualified personnel. The AstroLINK Quick Cal requires only a TC simulator and can be done at any time.
4) Connecting a TC causes a transient response that can distort the measurement temporarily. When calibrating or testing, wait several seconds after making the connection.
5) Our specifications are based on the NIST polynomial.

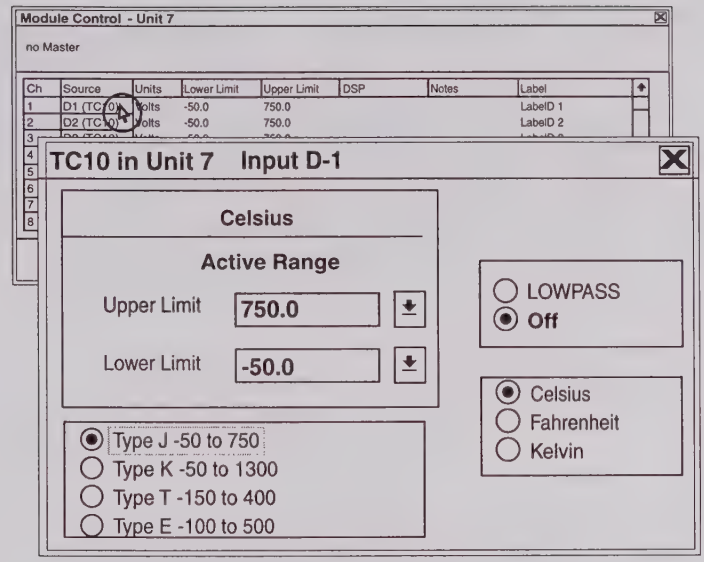
DSP functions

The DSP function includes an adjustable low-pass filter to 25 Hz.

Menu limits

TC-10 specifications are valid only within the ranges specified for each type.

• maximum span	1300° C
• minimum span	20° C
• span step	1° C
• minimum lower limit	-150° C
• maximum upper limit	1300° C



TC10 technical notes

The remainder of this section provides supplementary technical information regarding TC10 thermocouple measurements, reference junctions, and linearization issues.

Thermocouple measurements

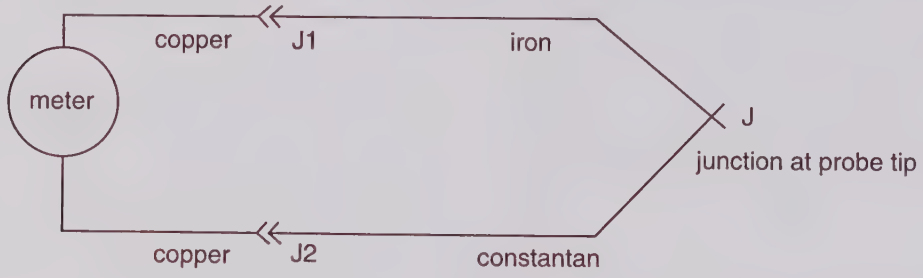
A thermocouple (TC) is a device that converts temperature into voltage. Thermocouples are based on the Seebeck effect. In this effect, a small temperature-dependent voltage develops at the junction between two different metals. Although the effect is true of all metals, some combinations of metals are much more useful than others when performing thermocouple measurements. Depending on the type of thermocouple device used, dependable performance in temperature ranges from -100° C to over 1200° C is achievable.

The table below lists the characteristics of the most popular thermocouple types. Voltages assume a reference junction at 0° C.

Type	Material	mV at 10° C	mV at 250° C
J	Iron/Constantan	0.507	13.553
K	Chromel/Alumel	0.397	10.151
T	Copper/Constantan	0.391	12.011
E	Chromel/Constantan	0.591	17.178

Reference junctions

Because connecting a voltmeter introduces additional junctions that must be taken into account, it is impractical to measure the TC junction voltage directly. The figure below illustrates this point.



The TC junction of interest shown above is labeled "J." However, the junctions labeled J1 and J2, created by connecting the meter, also generate Seebeck voltages. If junctions J1 and J2 are kept at the same temperature, they characteristically produce the same error voltage as a single junction of constantan and iron. This results from the law of intermediate metals. Therefore, the voltmeter reads the voltage created by the probe junction (J) minus the junction created by connecting to the amplifier. Usually, the second junction is referred to as the reference junction.

This leads to the observation that the voltage produced by a properly connected TC probe depends on the temperature of the reference junction as well as the temperature of the probe. To standardize the performance curves of thermocouples, the curves are based on measurements made with the reference junction at 0° C, also known as the "ice point." As a result, a measurement must be compensated for the actual temperature of the reference junction before it can be converted to temperature using standard curve data.

Proper compensation requires measuring the temperature of the reference junction and keeping input connections at the same temperature.

Linearizing TC measurements

Each pair of metals is characterized by a unique voltage-to-temperature relationship. For all commercial probe materials, this relationship is well known. The relationships are published as a standard with reference to ice point. Errors may occur when the curve of a probe deviates from the standard because of contamination by atmospheric particles, mechanical stress, or large magnetic fields.

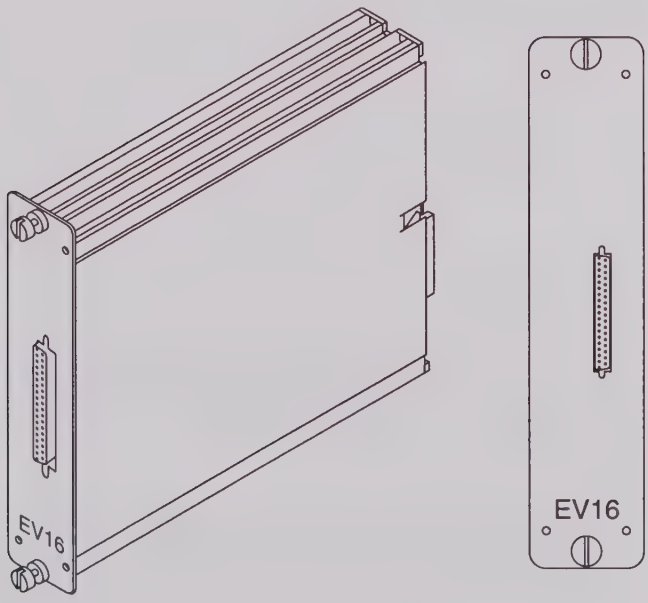
Generally, these curves are not linear, except over small regions. As a result, TC amplifiers must linearize measurements in converting the measurements to temperature readings.

9 EV16 EVENT MODULES

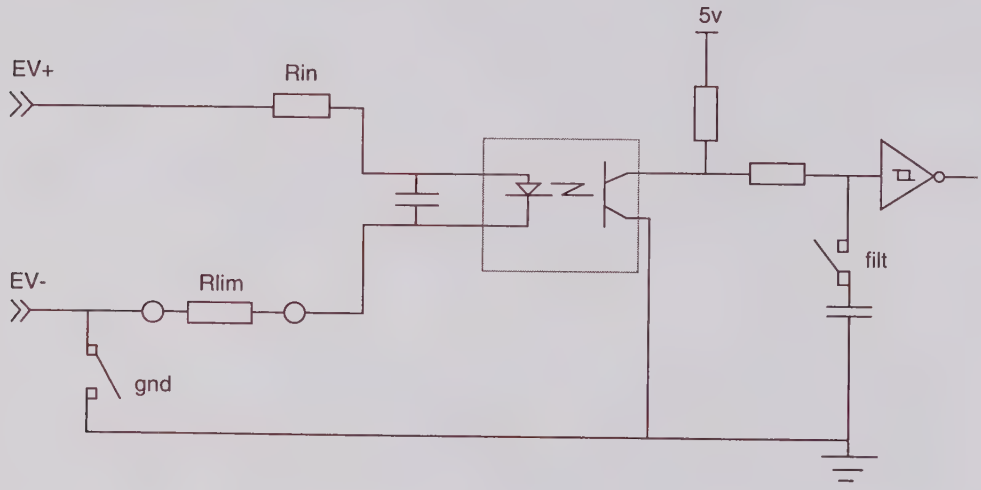
EV16 Binary Event Input Module

The EV16 binary event input module supports a maximum of sixteen binary event inputs. A maximum of six EV16 modules can be installed in a single AstroDAQ enclosure. Only four EV16 modules can be active at the same time for a maximum of 64 active events. The sixteen input event signals of the EV16 module are contained in a single waveform channel. When properly configured, each input can be electrically isolated from the chassis and from the other channels.

Using hardware provided on the module itself, each EV16 can be configured for a variety of input types. No AstroLINK menus are used to set up EV16 inputs. The EV16 module does not require calibration.



An EV16 input is illustrated in the diagram below. The switches labeled **filt** and **gnd** are located on the module circuit board (two switches per channel). The resistor **Rlim** is socketed and can be changed to accommodate a variety of applications. A zero (0) ohm resistor is included on the EV16 board. The resistor **Rin** has a value of 3000 ohms. **Rin** is not meant to be changed.



Board-mounted switches on the EV16

Switches for **gnd** are in groups of two and are located near the input connector. Switches for **filt** are in groups of eight and are located near the center of the board. Switch usage is shown in the table below.

	EV1	EV2	EV3	EV4	EV5	EV6	EV7	EV8
filt	SW1-1	SW1-2	SW1-3	SW1-4	SW1-5	SW1-6	SW1-7	SW1-8
gnd	SW3-1	SW3-2	SW4-1	SW4-2	SW5-1	SW5-2	SW6-1	SW6-2

	EV9	EV10	EV11	EV12	EV13	EV14	EV15	EV16
filt	SW2-1	SW2-2	SW2-3	SW2-4	SW2-5	SW2-6	SW2-7	SW2-8
gnd	SW7-1	SW7-2	SW8-1	SW8-2	SW9-1	SW9-2	SW10-1	SW10-2

EV16 input specifications

minimum pulse width	50 microseconds	(filt switch off)
input range	-5 V to 60 V	(Rlim = 0)
maximum IMV	250 V	(gnd switch off)
nominal threshold	2.3 V	(Rlim = 0)
hysteresis	0.05 V	
typical On current	0.3 mA	
maximum current	20 mA	
minimum input impedance	3000 ohms	(Rlim = 0)

EV16 input connector

The input connector of the EV16 module is a 37-pin D-shell. Pin descriptions for the EV16's 37-pin D-shell input are given below.

signal	pin number	signal	pin number
Ev 1 +	1	Ev 9 +	9
Ev 1 -	20	Ev 9 -	28
Ev 2 +	2	Ev 10 +	10
Ev 2 -	21	Ev 10 -	29
Ev 3 +	3	Ev 11 +	11
Ev 3 -	22	Ev 11 -	30
Ev 4 +	4	Ev 12 +	12
Ev 4 -	23	Ev 12 -	31
Ev 5 +	5	Ev 13 +	13
Ev 5 -	24	Ev 13 -	32
Ev 6 +	6	Ev 14 +	14
Ev 6 -	25	Ev 14 -	33
Ev 7 +	7	Ev 15 +	15
Ev 7 -	26	Ev 15 -	34
Ev 8 +	8	Ev 16 +	16
Ev 8 -	27	Ev 16 -	35
Pull-up 1	17	Pull-up 2	36
Pull-up 3	18	Pull-up 4	37
Pull-up 5	19		

Pull-up lines are connected to the AstroDAQ enclosure's logic supply (5 V) through a current-limiting resistor. The resistor has a value of 1000 ohms and a protection diode.

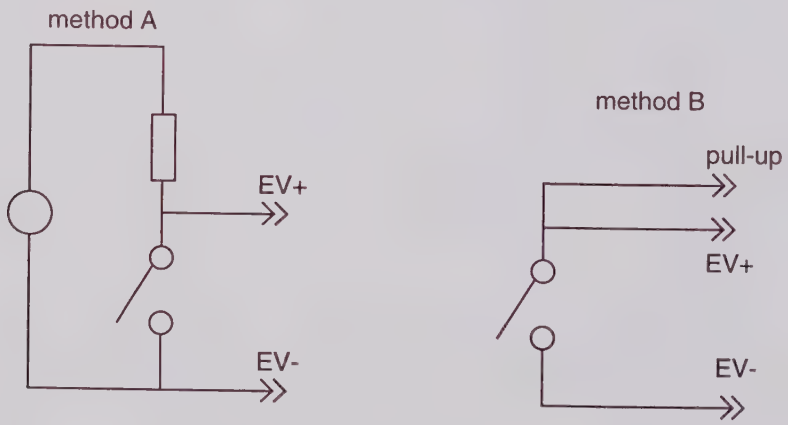
Configuring an EV16 module

The switch labeled **filt** in the EV16 input schematic should normally be set to OFF. When the **filt** switch is set to ON, the module's capacity to pick up transients is reduced by an approximate factor of 10. This may be useful in noisy environments.

The switch labeled **gnd** is used to determine the channel's reference. When the **gnd** switch is set to ON, the "EV -" input is connected to the AstroDAQ signal common. Signal common is ultimately connected to the AstroDAQ enclosure's chassis. When the **gnd** switch is set to OFF, the channel is isolated. Even when isolation does not seem to be required, it is generally advantageous to leave the **gnd** switch in the OFF position.

Monitoring switch closures

Switch closures are unique because there is actually no source. The simplest technique for monitoring a switch closure is to add a pull-up resistor. Two methods are shown in the circuit diagrams below.



In method A, a voltage source and pull-up resistor are added externally. If isolation is required, the user-supplied voltage source must be isolated. Voltage values for the source voltage and pull-up resistor must be greater than 2V for open and less than 1V for close. The current flow with the relay or switch open must be greater than 0.5 mA. Current flow can be as high as 20 mA without damage.

As an example, consider a user-supplied source of 5 V and a pull-up resistor of 1000 ohms. When the relay is closed, the source must supply 5 mA. When the relay is open, the EV16 looks like a 1.5 V diode in series with a 3000-ohm resistor. As a result, the source will supply a current of 0.875 mA and the voltage across the relay will be greater than 4 V.

Method B uses the internal pull-up resistor in the EV16 module. A maximum of five switch closures can be monitored in this way. Each of the internal pull-ups should be used with only one input. When using the internal pull-up, the **gnd** switch must be set to ON. With the **gnd** switch set to ON, the input is no longer isolated. Method B is useful for recording the state of pushbuttons.

Changing input threshold

The EV16 module is shipped with **Rlim** = 0. This provides a threshold of approximately 2.3 V and a maximum input of 60 V. Replacing the socketed resistor, **Rlim**, with a higher value increases the threshold. The maximum allowable differential input voltage is also increased.

As shown in the input stage diagram, it can be determined that the current flow (milli-amps) into the system is equal to:

(input voltage - diode voltage) / (3 + Rlim)

The diode voltage is approximately 1.3 V at the threshold point. Typically, a current of 0.3 mA will cause the channel to indicate High. Input current must never exceed 20 mA.

To increase the input threshold voltage, **Rlim** can be estimated with the following equation:

Rlim = (Vthreshold - 2.0) / 0.3 Rlim is given in Kilo-ohms

Because the optical components are not intended to function as precision comparators, this voltage level can easily vary by several tenths of a volt.

When **Rlim** is selected, the maximum safe differential voltage is found using the equation:

Vmax = 20 * (3 + Rlim) OR 250V (whichever is smaller)

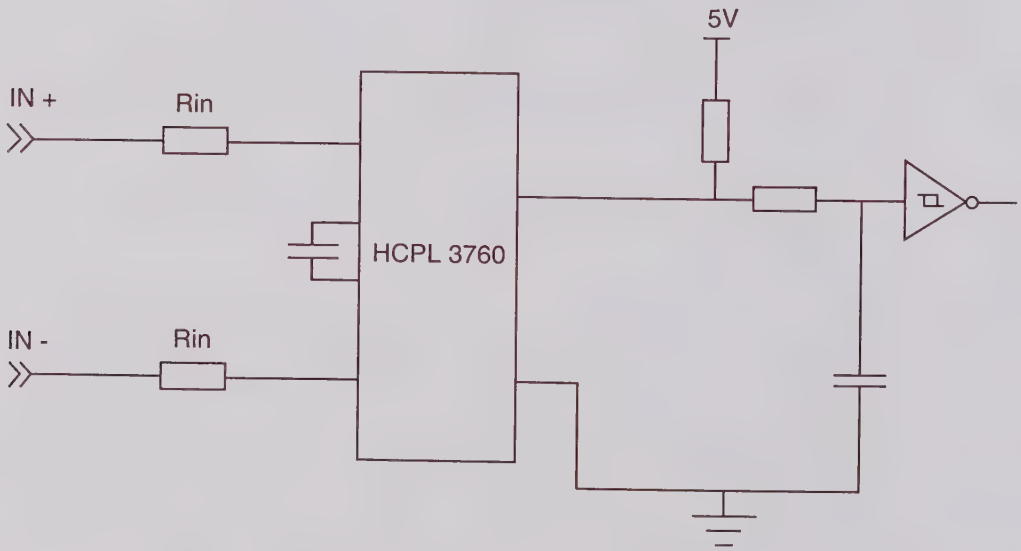
The differential input voltage (between EV+ and EV-) must never go below -5 V. Excess reverse voltage may damage the input.

EV16A High Voltage Event Module

Each EV16A module can monitor up to sixteen high voltage signals. A maximum of four EV16A modules can be installed in a single AstroDAQ enclosure. Inputs can be used to detect the presence of voltages between 60 and 240 VRMS. AC voltages with frequencies above 15 Hz will cause the event to be asserted. AC voltages with lower frequencies will cause the event to toggle. The resulting events can be monitored and acquired along with other AstroDAQ waveforms.

Each input is electrically isolated from both chassis and other channels. It is possible to monitor higher voltage inputs by changing the value of the current-limiting resistors. Contact Astro-Med Technical Support at 1-800-343-4039 for information on special versions.

An EV16A input is illustrated in the diagram below. The resistor **Rin** has a value of 22 kohms.

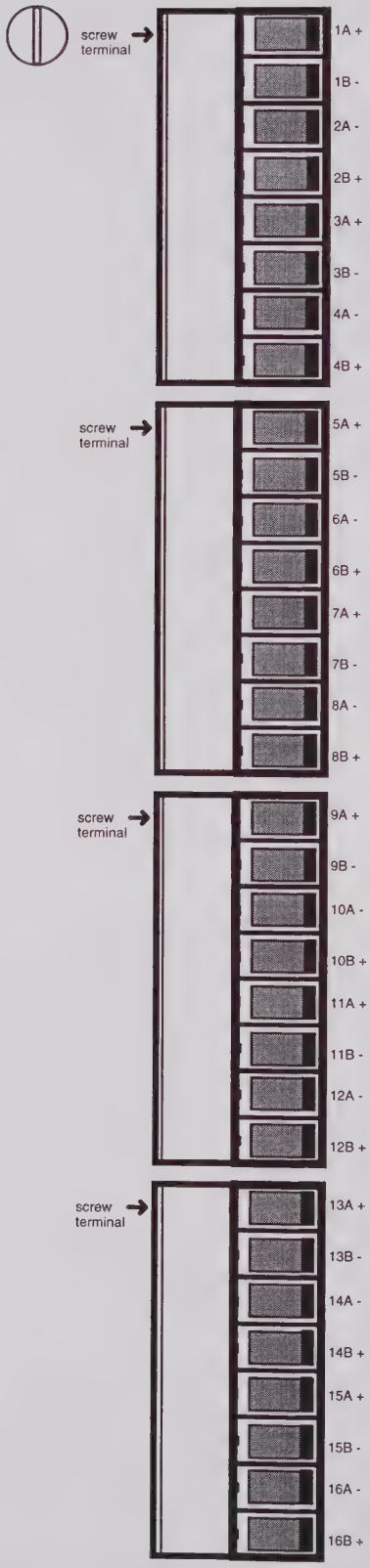


EV16A input specifications

maximum input voltage	240 VRMS
maximum input frequency	1000 Hz
minimum on frequency	15 Hz
maximum IMV	250 VRMS
nominal threshold	60 VRMS
maximum current	6 mA
nominal input impedance	40 kohms

EV16A input connector

The EV16A has four input connectors, each handling four input signals. Connections are made with screw terminals; wire should be stripped before being inserted. The screw adjacent to each connection should be loosened prior to connection and tightened after the wire is inserted. Input assignments are provided on the next page.



EV16A INPUT CONNECTOR ASSIGNMENTS			
One	Two	Three	Four
1A +	5A +	9A +	13A +
1B -	5B -	9B -	13B -
2A -	6A -	10A -	14A -
2B +	6B +	10B +	14B +
3A +	7A +	11A +	15A +
3B -	7B -	11B -	15B -
4A -	8A -	12A -	16A -
4B +	8B +	12B +	16B +

NOTE: When monitoring AC signals, the user can ignore the "+" and "-" designations.

10 C08 COUNTER MODULE

Each C08 Counter Module can count up to eight binary event inputs and up to six modules can be installed in a single AstroDAQ. The output of each channel can be independently configured either as a counter or as a rate meter. In either case, the module generates a waveform for each enabled channel, which can be monitored and acquired along with other AstroDAQ waveforms.

When configured properly, each input can be electrically isolated from both chassis and other channels.

C08 input specifications

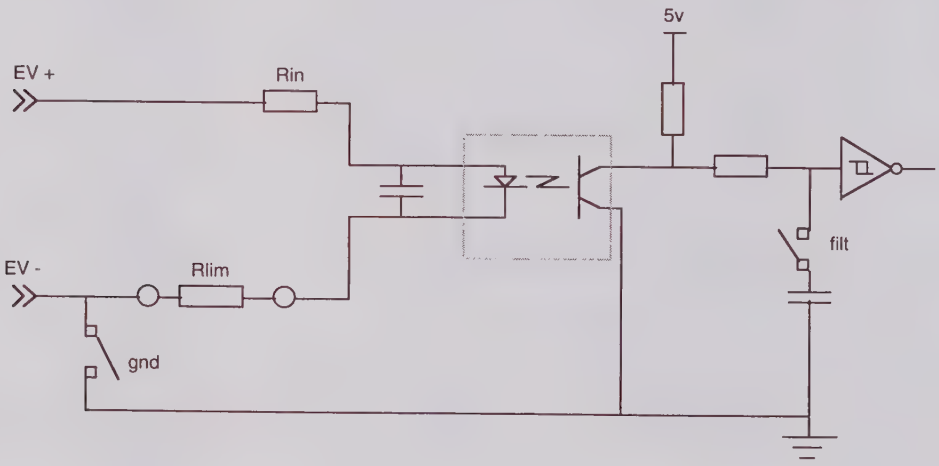
Some specifications depend on how the module is configured. C08 counts on the rise of the input pulse.

Minimum pulse width	50 microseconds	**filt** switch off
Maximum input rate	24 KHz	
Input range	-5 to 8 V	**Rlim** = 0
Maximum IMV	250 V	**gnd** switch off
Typical threshold	2.3 V	**Rlim** = 0
Hysteresis	0.05 V	
Nominal on current	2 mA	at threshold
Maximum current	20 mA	
Input impedence	400 to 1000 ohms	**Rlim** = 0
Dead time	0.02 to 500 milliseconds	selectable

C08 input stage

The diagram below illustrates one of the C08 inputs. Note the following:

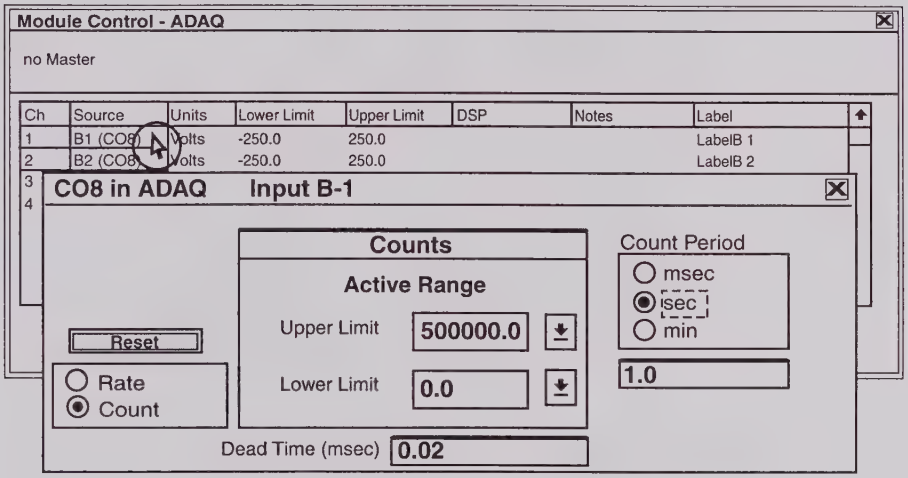
- The switches labeled **filt** and **gnd** are located on the module circuit board (two switches per channel).
- The resistor **Rlim** is socketed and can be changed by the user depending on the application.
- A 0-ohm resistor is included with the board.
- The resistor **Rin** has a value of 330 ohms and is not meant to be changed by the user.



Counter mode

When configured as a counter, the output of a channel is the current value of a counter, which is reset to zero at the start of each count period. A manual reset is also available. The count continues to increase as events are detected at the input, until the end of the count period, when the count is reset and the cycle begins again. The output waveform is updated with the current count every 200 microseconds (5000 Hz).

AstroLINK uses the following menu to control counter functions. *Note that the user units feature is not available and that a manual reset is provided.*



COUNT PERIOD --
The user selects one of the following count periods:

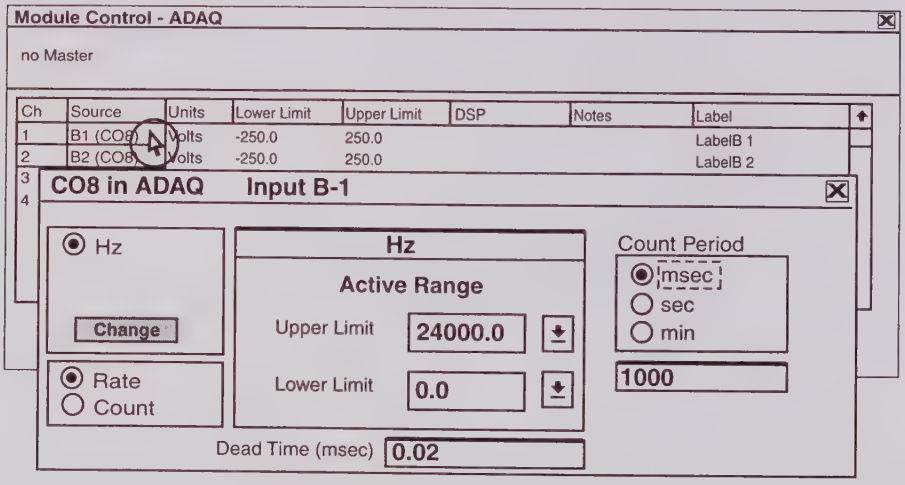
- **4 to 9999 milliseconds**
- **1 to 9999 seconds**
- **1 to 1200 minutes**

AMPLITUDE SCALE --
The module unit in counter mode is always Counts. Amplitude range limits are:

Minimum Span	**100**
Maximum Span	**100,000,000**
Span Step	**1**
Minimum Lower Limit	**0**
Maximum Up Limit	**100,000,000**
Resolution	**1**

Rate meter mode

When configured as a rate meter, the module unit is Hertz (Hz) and the output is updated at the end of each count period. Longer count periods have better output resolution, but the response time for the channel decreases. AstroLINK uses the following menu to control rate meter functions. The choice of count period is limited to milliseconds.



COUNT PERIOD --
The user selects a value from 5 to 9,999 milliseconds.

AMPLITUDE SCALE --
The module unit is Hertz (Hz). Amplitude range limits are:

Maximum Span	**24,000**
Span Step	**1**
Minimum Lower Limit	**0**
Maximum Up Limit	**24,000**

Longer count periods have better output resolution, so minimum span and resolution specifications depend on the selection for count period. This is summarized in the following table, with count period given in milliseconds and all other values in Hz. The user can convert Hz to other user engineering units using the standard AstroLINK menu.

Count Period	Maximum Span	Minimum Span	Resolution/Error
5 to 9	24,000	10,000	200
10 to 49	24,000	2,000	100
50 to 99	24,000	1,000	20
100 to 499	24,000	500	10
500 to 999	24,000	200	2
1000 to 9999	24,000	10	1

C08 input connector

The input connector is a 37-pin D-shell with the following pinouts:

Signal	Pin Number	Signal	Pin Number
ch 1 +	1	ch 5 +	5
ch 1 -	20	ch 5 -	24
ch 2 +	2	ch 6 +	6
ch 2 -	21	ch 6 -	25
ch 3 +	3	ch 7 +	7
ch 3 -	22	ch 7 -	26
ch 4 +	4	ch 8 +	8
ch 4 -	23	ch 8 -	27
Pull-up 1	17	Pull-up 2	36
Pull-up 3	18	Pull-up 4	37
Pull-up 5	19		

Pull-up lines are connected to the AstroDAQ logic supply (5 V) through a current-limiting resistor with a value of 1000 ohms and a protection diode.

Board-mounted switches

Switches for **gnd** are located near the input connector in groups of two. Switches for **filt** are located near the center of the board in groups of eight. Usage is shown below.

	ch 1	ch 2	ch 3	ch 4	ch 5	ch 6	ch 7	ch 8
filt	SW1-1	SW1-2	SW1-3	SW1-4	SW1-5	SW1-6	SW1-7	SW1-8
gnd	SW3-1	SW3-2	SW4-1	SW4-2	SW5-1	SW5-2	SW6-1	SW6-2

Configuring C08

The switch labeled **filt** in the schematic should normally be set to OFF. Setting this switch to ON will reduce the ability of the module to pick up transients by about a factor of 10. This may be of use in a noisy environment.

The switch labeled **gnd** is used to determine the channel's reference. When this switch is ON, the ch- input is connected to the AstroDAQ signal common, which is ultimately connected to the AstroDAQ chassis. When this switch is OFF, the channel is isolated. It is generally advantageous to leave this switch in the OFF position, even when isolation does not seem to be required.

Monitoring switch closures

Refer to "Monitoring switch closures" in chapter 9, EV16 event modules.

Changing input threshold

The C08 module is shipped with **Rlim** = 0, which provides a threshold of approximately 2.3 volts and a maximum input of 8 volts. This means that differential voltages below 2.3 will be seen as a Low, while voltages above 2.3 will be seen as a High. Because of the nature of the optically coupled input, this threshold is not precise and may vary by several tenths of a volt from channel to channel. Replacing the socketed resistor, **Rlim**, with a higher value increases the threshold and also increases the maximum allowable differential input voltage.

Refer to "Changing input threshold" in chapter 9, EV16 event modules, for information on determining the value of **Rlim** for a particular threshold; the values will differ because a different optical isolator is used.

The differential input voltage (between ch+ and ch-) must never go below -5 volts. Excess reverse voltage may damage the input.

11 AM1 ACCESSORY MODULE

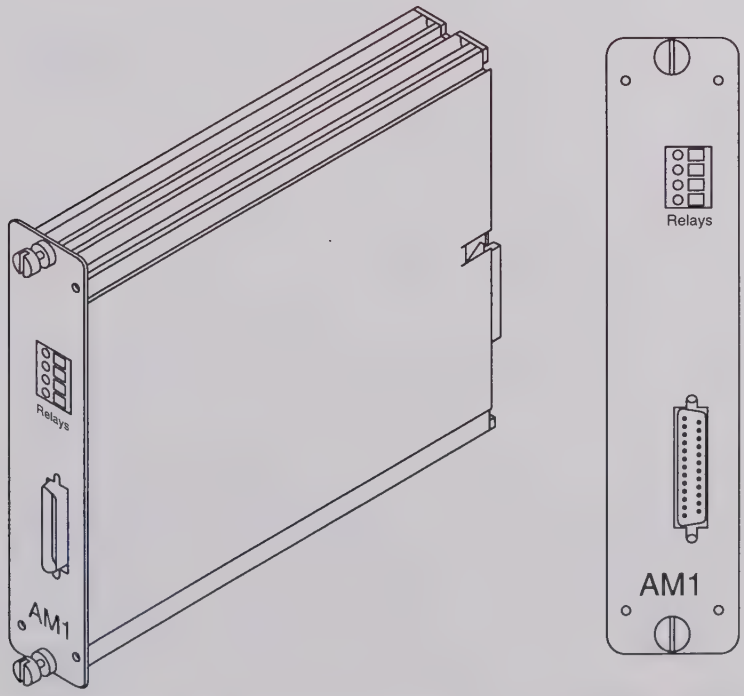
The AM1 accessory module provides advanced trigger capabilities and hardware inputs and outputs (I/O) used to control a test cycle. The hardware I/Os can be controlled by the AstroLINK sequencer found on the AstoLINK tool bar. Only one AM1 accessory module should be installed in an AstroDAQ enclosure.

The AM1 accessory module provides the following features:

- a maximum of thirty independent window triggers
- four slew-rate triggers*
- AND/OR trigger combinations
- four optically coupled logic inputs for use in trigger generation and sequencing
- four TTL outputs that can represent waveform triggers or be controlled by the Sequencer
- a TTL clock that can be set to generate frequencies from 1 to 50,000 Hz
- two isolated relays controlled by AstroLINK software (5 A at 250 VAC or 30 VDC)
- two analog outputs (±5 V) controlled by AstroLINK software

Each AM1 module can broadcast a maximum of thirty events associated with waveform limit testing, which can be used in conjunction with the AstroLINK Alarm display.

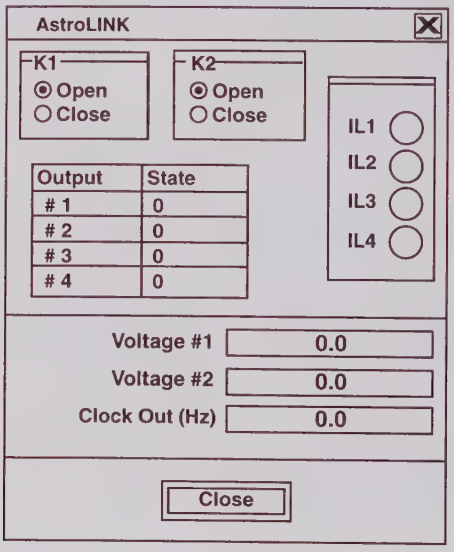
* Astro-Med offers an AM2 accessory module which includes 30 slew-rate triggers, but provides no hardware inputs and outputs. Contact Astro-Med Technical Support at 1-800-343-4039 for further information.



AM1 accessory module control menu

The I/O circuitry of the AM1 is controlled through the Accessory Control menu (described below) or the Sequencer tool (described in chapter 17).

To access the Accessory Control menu, click AstroLINK's pull-down Utilities menu and select Accessory Control.



The Accessory Control menu provides a convenient means for evaluating the AM1 input/output capabilities. The notes below apply to the Accessory Control menu.

- K1 and K2 refer to Relays #1 and #2.
- IL1, IL2, IL3, and IL4 refer to AM1 input logic levels. The circular indicators change color to reflect the current status of each level based on a one-second poll.
- The four-element state table is used to control the output logic levels provided by AM1. States are changed by clicking on the 0 or 1.
- Voltages #1 and #2 are analog output levels provided by AM1. The levels can be varied by entering values between -10 and +10 (volts).
- Clock output is used to determine the frequency of the AM1 output clock. The desired output frequency is entered in Hz.

Triggering features of the AM1

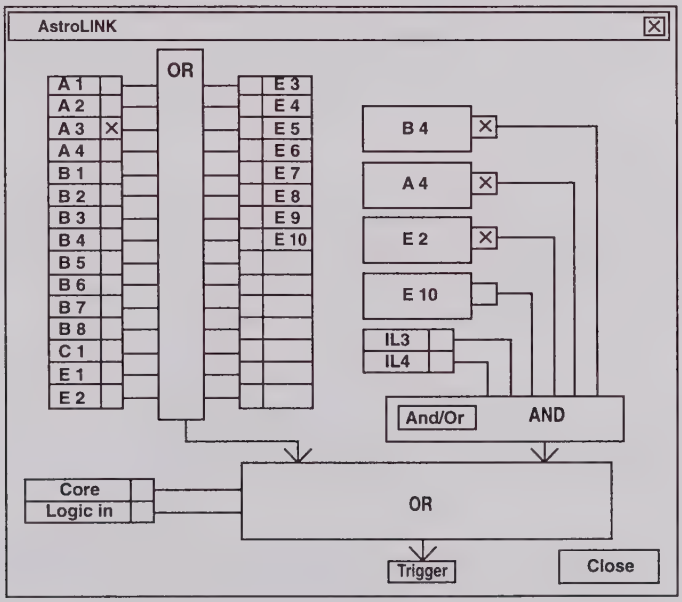
When the AM1 is installed in an AstroDAQ, the module is recognized by AstroLINK software and the Trigger window expands to support additional features.

To access the Trigger window (shown below): click the Setup Waveform Triggering icon *or* click the Windows pull-down menu in the main toolbar and select Trigger.

The trigger menu is organized to illustrate the logical relationships between potential trigger sources. Each potential trigger source can be enabled or disabled by clicking on the small square switch box associated with the source. The switch box has two states:

☐ = trigger source is not used (disabled)

☒ = trigger source is used (enabled)



The three main logic sections shown in the menu are described in the following paragraphs.

Fixed channel OR stage

The value of each active waveform channel is tested using an independent amplitude window. If the channel is enabled, the result is OR'd with other triggers to generate the final trigger. The user can modify the upper and lower bounds of the window by clicking on the trigger element. The window can only be adjusted if the trigger element has been enabled. Event channels can also be used as triggers based on a user-defined pattern.

Variable channel AND/OR stage

The variable channel AND/OR stage implements either of the following equations.

Output = PT1 AND PT2 AND PT3 AND PT4 AND IL3 AND IL4

Output = PT1 OR PT2 OR PT3 OR PT4

Clicking the AND/OR button selects between the two equations. The label of the AND/OR stage changes from AND to OR indicating the equation to be used. The output of this stage is OR'd with other trigger elements to create the final trigger.

PT1, PT2, PT3, and PT4 are independent trigger elements that can be defined by the user. By default, a trigger is generated when the selected waveform exceeds the specified upper and lower bounds of the window. Other trigger tests include Inside Window and Slew. They can process any active channel based on a user-determined slew rate.

Final OR stage

The final OR stage allows the user to add one of three elements to the final trigger equation. The three elements are:

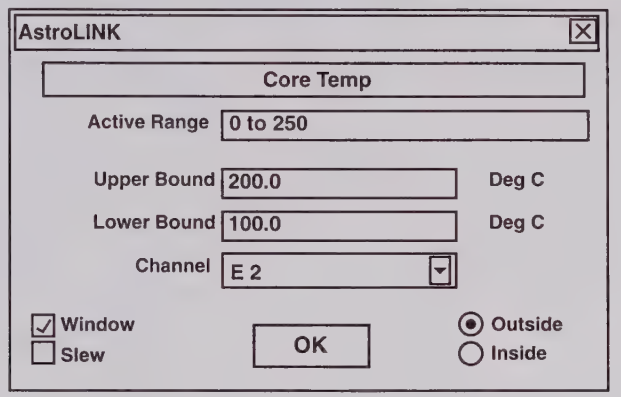
- core trigger — single-channel slope/level trigger provided by all AstroDAQs (The core trigger is described in chapter 13, "Core trigger," and in chapter 2, "Trigger.")
- logic in — a logical combination of the logic inputs provided by the AM1

The trigger menu shown previously would result in the following equation:

- trigger if — A3 is outside window;
  OR B4 and A4 and E2 meet trigger requirements simultaneously.

Variable channel trigger elements (PT1 - PT4)

These trigger elements can be independently configured by clicking the desired channel label. The channel label must have been enabled previously by clicking the switch box as described in "Triggering features of the AM1" earlier in this chapter. The variable channel trigger window is shown below.



In the example above, the signal source is E2, a thermocouple amplifier set for an active range of 0° to 250° C. The channel label located at the top of the window is "Core Temp." The trigger has been set to "outside," which means that the trigger is based on the waveform moving outside the window defined by the upper and lower bounds. Trigger conditions are met when the temperature rises above 200° C or falls below 100° C.

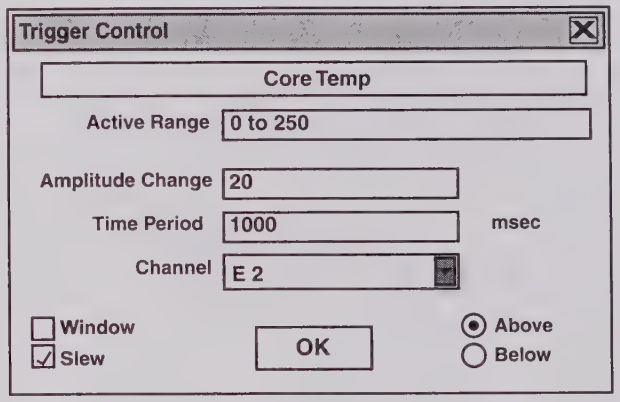
The window can be changed by clicking either of the bounds and typing a new value (the value must be within the active range, and the lower bound must not exceed the upper bound). Press the Return key or click another element to verify the entry. *The window is not altered until it is closed by clicking OK.*

The assigned channel can be changed by clicking the channel pull-down menu and choosing one of the listed channels.

The trigger windows used by variable channel trigger elements are not dependent on windows used by fixed channel trigger elements.

Slew triggering

Any of the variable channel trigger elements can be configured to generate a trigger based on the change in waveform amplitude over a fixed time period. This is referred to as a slew trigger. A typical slew trigger menu is shown below.



To configure a slew trigger:

1 Set the Time Period field to a value between 1 and 10,000 (milliseconds).

2 Set the Amplitude Change field to a number in user engineering units. *(The Amplitude Change must always be a positive number greater than approximately 0.2% of the active range; the change entry must not exceed half the active range.)*

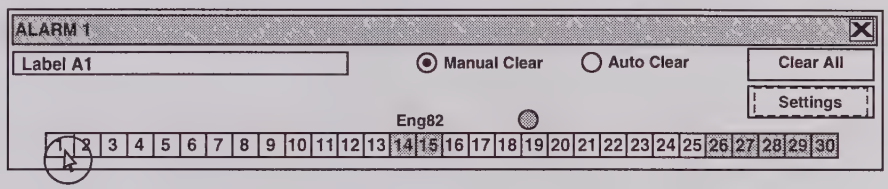
The trigger can be generated when the change in waveform amplitude is above or below the preset value.

- The "Above" slew trigger can be used to detect noise or sudden changes in frequency.
- The "Below" slew trigger is useful for detecting drop out or cessation of activity.

The choice of time period does not affect the slew trigger's ability to detect transients. However, time period does determine the latency or time delay between the transient and the trigger being asserted. This is discussed further in the Technical Notes paragraphs in the final pages of this chapter.

Monitor alarm mode

AstroLINK's real-time Monitor 1 can be run in an Alarm mode. The Alarm window is shown below.



The Alarm window provides one or more rows of indicator lights representing the channels of each connected AstroDAQ equipped with an AM1 module.

If no activated AM1s are found, a message will indicate no AM1, whenever an attempt is made to use the Alarm mode.

The following visual indications apply:

- The unit label (of each AstroDAQ system) is shown immediately above the row of lights (channels) associated with that system.
- A trigger indicator, which turns yellow when a trigger is active, appears at the right side of the unit label.
- Unused channels are grayed out.
- The text block at the upper left of the window indicates the channel label of the box at which the cursor is directed.

An AM1 is activated as an alarm source when the module has been authorized to broadcast Fixed Channel trigger results as events. This is done using the Enable/ Disable Channels selection in the Make Test window (see chapter 16).

To activate an AM1 module, enable the first two available AM1 channels in the potential channel list. When activated, these trigger events appear to the system as event channels that can be monitored, recorded, or acquired along with other signals. The third AM1 channel is reserved for future applications. The first fifteen Fixed Channel triggers are put on the first AM1 event channel. The remaining Fixed Channel triggers are on the second AM1 event channel.

NOTE: Because adding channels may change channel number assignments, AM1 channels should be enabled before setting trigger levels. An alternative is to install the AM1 in slot F. Because channel numbers are assigned in order of slot, changes to an AM1 in slot F will not affect other channel assignments.

Trigger boundaries are set in the Trigger window. See "Triggering features of the AM1" presented earlier in this chapter. (See "Trigger" in chapter 2 and "Core trigger" in chapter 13 for information on the core trigger.)

Two options are available for clearing a trigger: auto clear and manual clear. The Auto Clear option permits trigger alarms to be cleared automatically after they are generated. The Manual Clear option lets the user review the alarms before they are cleared.

When the Manual Clear option is selected, the alarm indicator (unit indicator and channel indicator) will remain lit, even though they have since cleared, until the user clicks the indicator boxes to clear them.

Clicking the channel box will clear the alarm for a given channel. Clicking the trigger indicator for the system (near the unit label) will clear the system trigger, but will not clear the alarms for individual channels. When using the Manual Clear option, both the channel indicator and the unit indicator must be clicked in order to clear all alarms.

AM1 relay connector

Connections are made by inserting stripped wire ends and tightening the adjacent screw. The screw may have to be loosened before a wire can be inserted. Connections 1A and 1B are contacts for the Relay #1, while connections 2A and 2B are contacts for relay #2. It is intended for wire sizes from 22 to 14 AWG.

AM1 signal connector

The signal connector is a 25-pin D-shell with the following pinouts:

Signal	Pin Number	Signal	Pin Number
Logic In 1	1	Logic Out 1	16
Logic In 2	14	Logic Out 2	4
Logic In 3	2	Logic Out 3	17
Logic In 4	15	Logic Out 4	5
Dig Common	3	Dig Common	18
Clock Out	19	Relay Intlk 1	7
Dig Common	8	Relay Intlk 2	20
Analog Out 1	21	Analog Out 2	9
An Common	22		

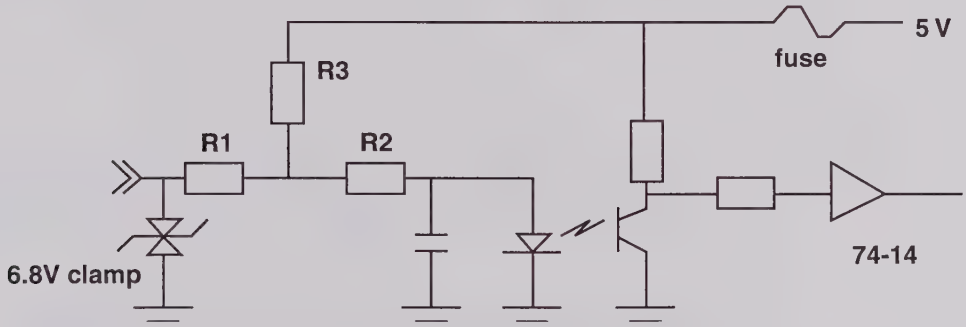
All other lines are reserved and should not be used.

Input/Output (I/O) circuits

The paragraphs that follow discuss the I/O circuitry provided by the AM1.

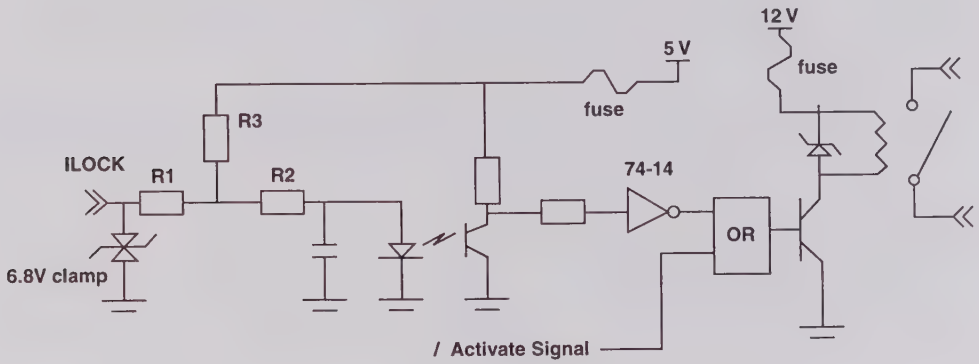
Digital inputs

The circuit shown below is used for the AM1's four Logic Inputs and Relay interlocks. The circuit is compatible with most TTL voltage levels and switch closures. **R1** is 10 ohms. **R2** is 3000 ohms. **R3** is 1000 ohms. The input voltage threshold is 1.5 - 1.7 V with an ON current of 0.5 mA.



Relays

The AM1 provides two independent, isolated relays that can be controlled through AstroLINK. Both relays use the circuit shown below.



The interlock (ILOCK) input is compatible with most TTL voltage levels and switch closures. **R1** is 10 ohms. **R2** is 3000 ohms. **R3** is 1000 ohms. ILOCK must be ON for the relay to close. Refer to "Digital Inputs" on the previous page for input characteristics.

The /Activate Signal is generated in response to AstroLINK commands.

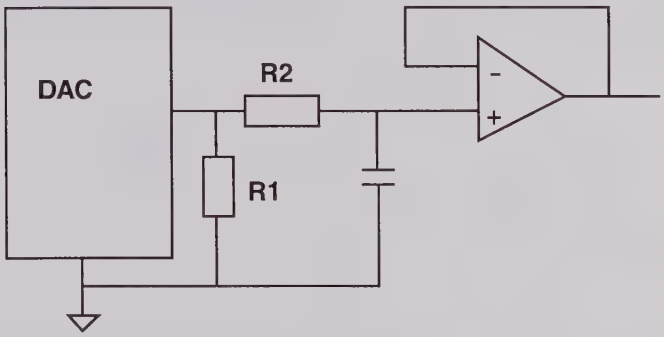
The relay is sealed and has the following breakdown voltage ratings:

- 1000 Vrms between open contacts
- 4000 Vrms between contact on coil

The relay is intended to switch up to 5 amps at voltages up to 250 VAC or 30 VDC. Typical operate and release times are 5 to 10 milliseconds. The maximum operating rate at full load is 20 cycles per minute.

Voltage level outputs

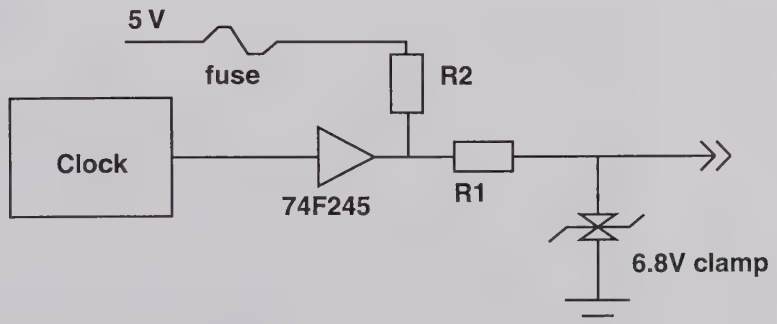
The AM1 provides two independent digital-to-analog converters (DACs). The DACs can generate voltage levels from -5 V to + 5 V. The DAC output circuit is shown below.



R1 is 10 megohm. **R2** is 3.6 kilohm. Individual channel output buffers can support loads up to 20 mA. Total current drive capability for both channels is limited by fuse elements described later in this chapter.

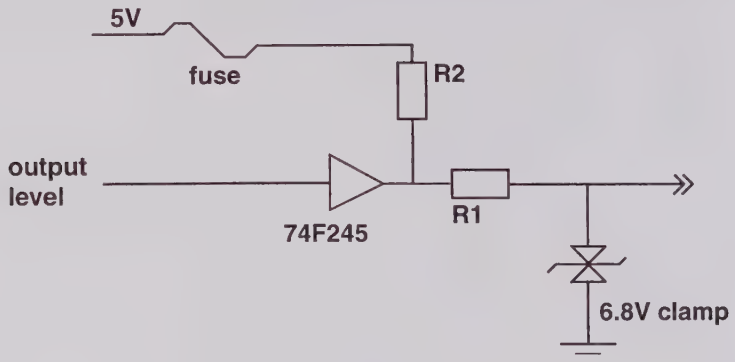
Clock output

Shown in the schematic below, clock output is designed to drive TTL circuitry.



Logic outputs

Shown in the schematic below, logic outputs are designed to drive TTL circuitry.



Onboard fusing

The AM1 module contains fusing to minimize damage in cases of improper connection or the application of unexpected voltage. Fuse elements are PTC current limiters that automatically recover when a fault is removed. They should not need to be replaced.

There are fuse elements on each of the voltages supplying I/O circuitry (+5, +12, and -12). Fuse elements are designed to trip at currents between 25 and 50 milliamps.

Technical notes

The following paragraphs provide additional details on specific AM1 functions.

Slew trigger processing

When checking slew, the AM1 always samples waveforms at the full AstroDAQ rate. Each sample is compared against the current minimum and maximum values of the waveform. These minimum and maximum values are altered if exceeded by the present sample. At the end of a fixed period of time, an amplitude delta is created by subtracting the minimum value from the maximum value. This amplitude delta is compared to the user-selected slew amplitude. A partial trigger is asserted if conditions are met. The minimum and maximum values are then set to the current sample value and the cycle begins again.

This technique ensures that the slew trigger does not miss any transients because all samples are examined. The technique also implies that the trigger is only updated at the end of each time period. If the maximum time period of 10 seconds is selected, a delay of nearly 10 seconds could exist between a transient occurrence and the actual generation of a trigger. Therefore, the selected time period should be as small as possible.

Slew rates for sinusoids

In theory, the slew rate of a waveform is the mathematical derivative (instantaneous slope) of the waveform at a point in time. In the AM1, slew is defined as the largest change in amplitude over a fixed period of time. Depending on the waveform and time period chosen, a significant difference may exist between these two values.

A sinusoidal waveform with an amplitude that varies around 0 from -A to +A has the equation:

$$A \times \text{Sine}(2\pi F t) \quad \text{where } F = \text{frequency in Hz}$$

The fastest rate of change is found at the point where the waveform crosses 0. Therefore, the maximum change in amplitude (ΔA) for a fixed time period (ΔT) is:

$$\text{maximum } \Delta A = 2A \times \text{Sine}(\pi F \Delta T) \quad \text{for } F\Delta T < 0.5$$

Similarly, the slowest point of a sinusoid is at the peak. This fact is used to derive an equation for the minimum change in amplitude (dA) over a fixed period of time (ΔT):

$$\text{minimum } \Delta A = A \times [1 - \text{Sine}((\pi/2) - (\pi F \Delta T))] \quad \text{for } F\Delta T < 0.5$$

When the value of $F\Delta T$ equals 0.5, ΔT must include half of the sinusoidal cycle. Looking at a sine wave, it can be seen that, if ΔT includes more than half of the cycle, the maximum amplitude is 2 A. Additionally, the minimum amplitude change in one half cycle is A. When ΔT includes the entire cycle ($F\Delta T = 1$), the minimum amplitude change must be 2 A.

The table below is based on these observations. Amplitude change is given in terms of A. Note that the maximum can never exceed 2A (peak-to-peak). Minimums under 1% are not given.

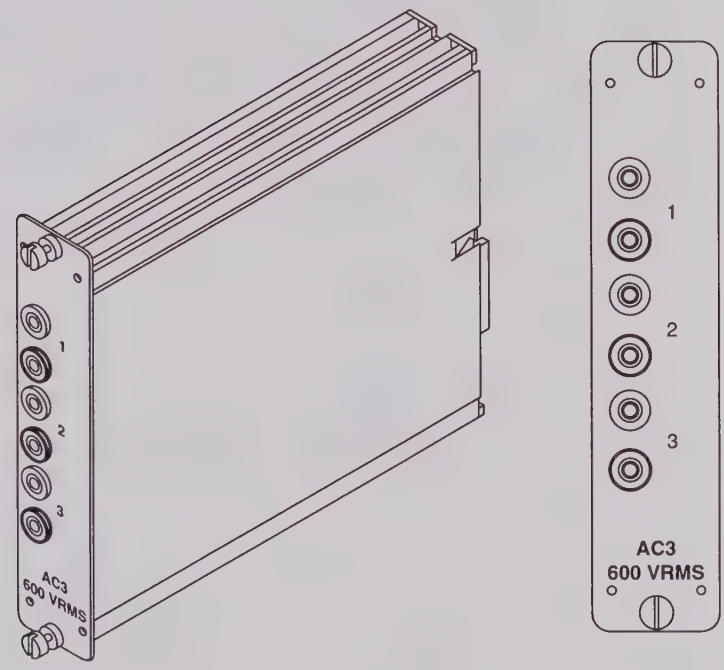
	1 msec time period		5 msec time period		10 msec time period	
frequency	**max dA**	**min dA**	**max dA**	**min dA**	**max dA**	**min dA**
1 Hz	<0.01 A	<0.01 A	0.03 A	<0.01A	0.06 A	<0.01 A
10 Hz	0.06 A	<0.01 A	0.31 A	0.01 A	0.62 A	0.05 A
20 Hz	0.12 A	<0.01 A	0.62 A	0.05 A	1.2 A	0.19 A
30 Hz	0.19 A	<0.01 A	0.91 A	0.11 A	1.6 A	0.41 A
60 Hz	0.37 A	0.02 A	1.6 A	0.3 A	2 A	
100 Hz	0.62 A	0.05 A	2 A	A	2 A	2 A
250 Hz	1.41 A	0.29 A	2 A	2 A	2 A	2 A

Detecting drop-out

By electing to test for slew values below the pre-set threshold, a drop-out detector can be created. The detector will generate a trigger when a signal disappears. One application is AC power, where the normal voltage waveform is a sinusoid with a frequency of 60 Hz. From the table on the previous page, it can be seen that such a waveform should never have an amplitude change of less then 30% of the peak value over a five-millisecond period. Setting the slew trigger to look for an amplitude change of under 20% (to account for noise and other effects) allows the AM1 to detect single cycle AC drop-out.

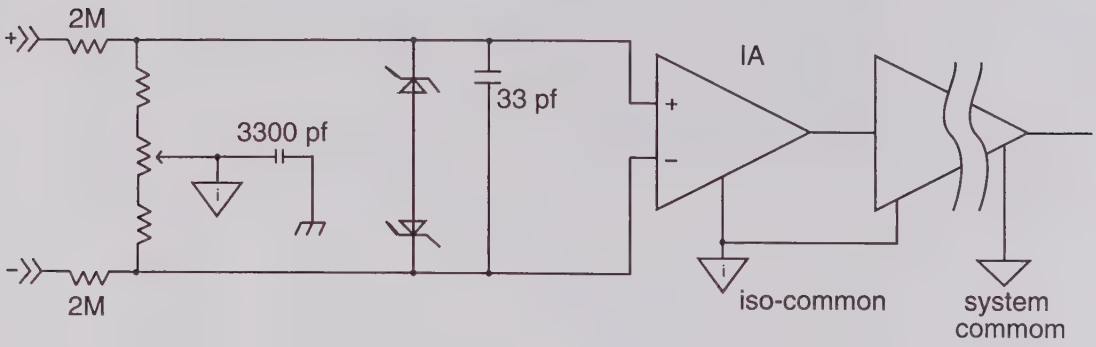
12 AC3 HIGH VOLTAGE INPUT MODULE

The AC3 high voltage input module is an isolated 3-channel voltage input module that is ideal for monitoring AC voltages. Each channel can be recorded as a peak-to-peak value, an RMS value, and the frequency of the waveform. The AC3 can condition signals up to 600V, making it an ideal choice for high voltage 3-phase monitoring.



The AC3 uses digital signal processing to calculate the RMS and frequency of the input, so that each of the three channels of input are actually nine different channels in the AstroDAQ. This allows a complete view of the waveform. All of these channels can be displayed on the real-time monitors as well as recorded to the internal hard drive.

The input stage of a AC3 channel is shown in the diagram below.



AC3 input connectors

The AC3 voltage input module uses guarded banana jack inputs. The yellow input is the positive input; the black input is the negative.

AC3 channel specifications

user input connector	guarded banana jack
maximum input	600 VRMS
frequency response	-1 dB at 500 Hz
input coupling	DC
maximum range	peak-to-peak: ±850 V RMS: 0 to 600 VRMS frequency: 0 to 1000 Hz
maximum span	peak-to-peak: 1700 V RMS: 600 VRMS frequency: 1000 Hz
minimum span	peak-to-peak: 100 V RMS: 40 VRMS frequency: 10 Hz
maximum IMV	600 VRMS
CMR/IMR	>60 dB at 60 Hz
minimum input impedance	2 megohm
dielectric strength	2200 VRMS, 60 seconds, 60 Hz, channel-to-chassis
intrinsic noise	peak-to-peak: < 100 mV + 0.1% fullscale RMS: <150 mV + 0.1% fullscale frequency: <0.10 Hz + 0.2% fullscale
accuracy	peak-to-peak: 0.5% of value + 0.3 V RMS: 0.5% of value + 0.3 V frequency: ±0.10 Hz
thermal stability	20 mV per degree C

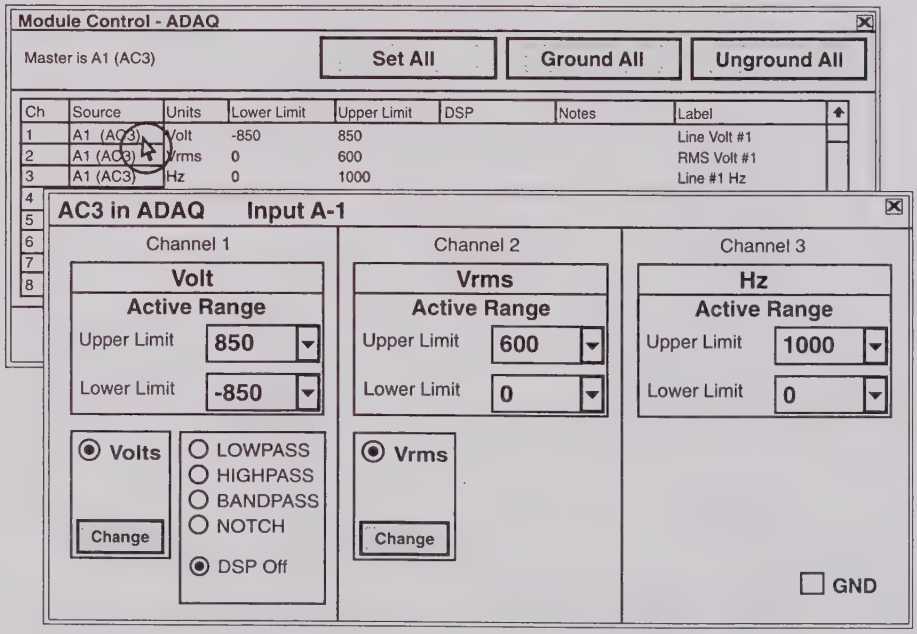
Note: Specifications are valid for input frequencies from 40 Hz to 450 Hz. Frequency measurements are valid for signals with amplitudes above 95 VRMS.

AC3 parameter-adjustment window

The AC3 parameter-adjustment window is used to define the following AC3 operating parameters:

- each input can provide three channels as a peak-to-peak value, an RMS value, or the frequency of the waveform
- grounding the input, if desired
- defining the signal as user-specified engineering units
- defining the upper and lower limits of the signal ranges
- enabling any of the following filters: low-pass, high-pass, band-pass, or notch

The AC3 parameter-adjustment window is accessed by clicking any AC3 channel listed in the Module Control window. An example of the AC3 parameter-adjustment window is shown below.



PART III

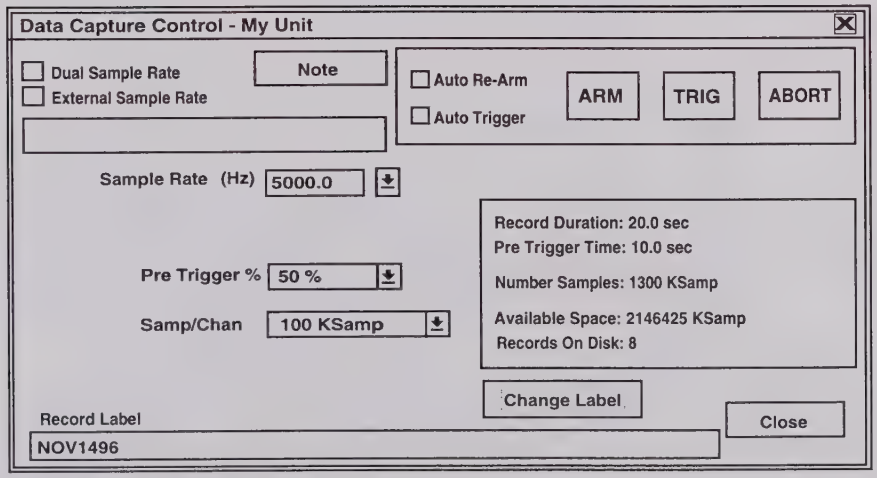
ASTROLINK® SOFTWARE

13 DATA CAPTURE

Each AstroDAQ can capture a maximum of thirty channels at rates up to 5000 samples per second per channel. The AstroDAQ's internal hard disk is used for data capture. Data capture does not require host resources.

Click the *Data Capture* icon to open the Data Capture Control window.

data capture



Data capture control window

The Data Capture Control window provides controls used to:

- arm and trigger the system
- define data capture parameters

The window also contains a status area that dynamically shows the effects of the selected parameter settings on record duration, size, and other variables.

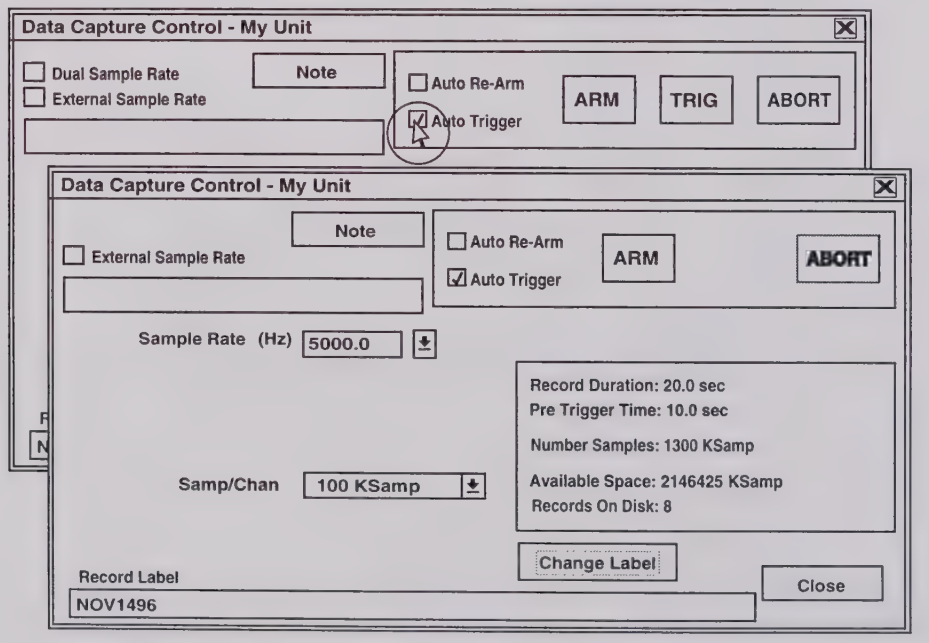
WARNING: Switching off power while a capture is active will cause a loss of data. However, battery backup will prevent a loss of data if the unit is accidentally unplugged.

Arming and triggering the system

Clicking the Auto Re-Arm selection box will enable the Auto Re-Arm function. When enabled, the AstroDAQ automatically re-arms after each data capture. When Auto Re-Arm is not selected, the Arm button is used to manually re-arm the AstroDAQ after a data capture has been performed.

Clicking the Auto Trigger selection box will enable the Auto Trigger function. The Trig button is used to initiate a manual trigger when Auto Trigger is not selected.

The Abort button is used to manually cancel a data-capture acquisition.

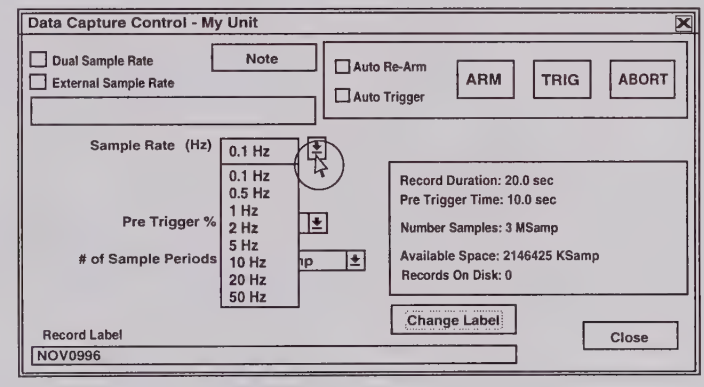


Defining data capture parameters

The following parameters of the Data Capture Control window determine the quantity of data to be captured, the time duration of the data capture, and the amount of pre- and post-trigger data to be captured.

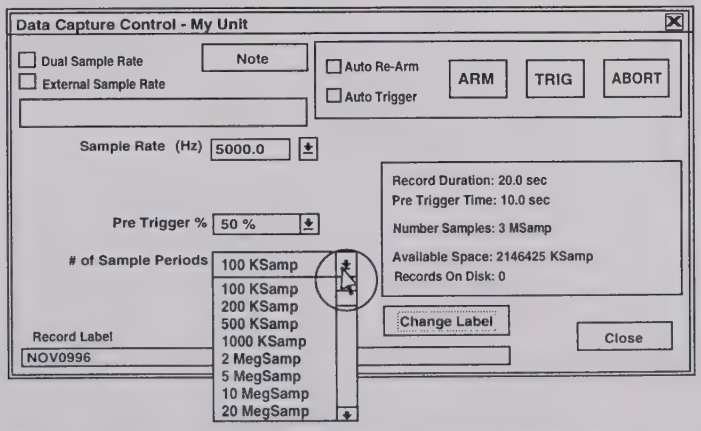
- sample rate

Expressed in hertz, sample rate is the frequency at which the selected waveforms will be sampled for data. Sample rate can be thought of as the number of sample periods per second.



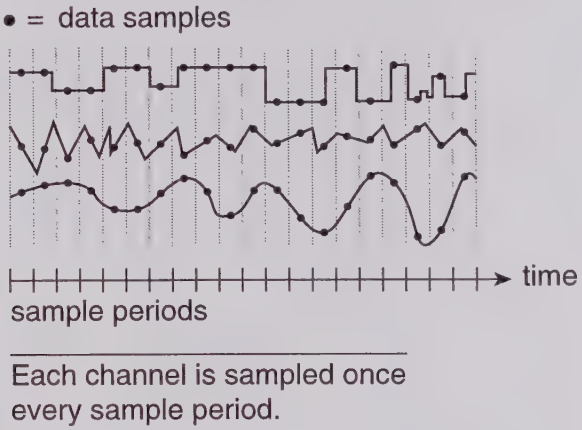
- number of sample periods

A sample period is a time period during which data samples are collected from the selected waveforms. The number of sample periods is expressed in a user-selectable quantity of kilosamples or megasamples. The Data Capture Control window with an open sample-period selection box is shown below.



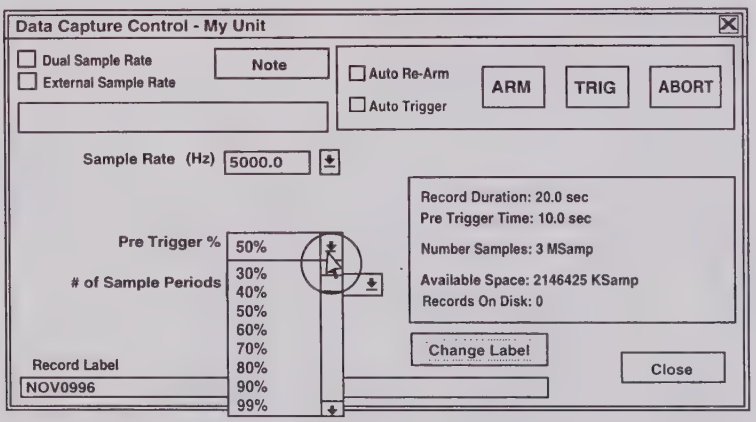
The total time required for a data capture is derived by dividing the number of sample periods by the selected sample rate.

sample periods / sample rate determines duration



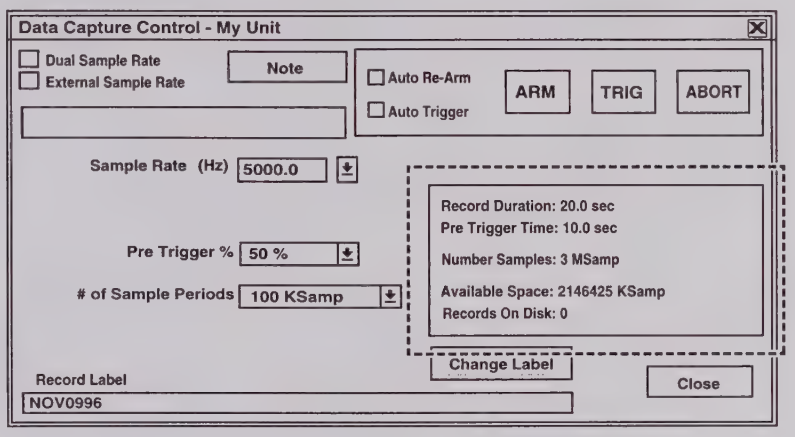
- specifying the percentage of pre-trigger data

The amount of pre-trigger data to be included in a data capture record is user-selectable in the percentages shown in the window below.



Summarizing the results of parameter choices

The Data Capture Control window provides a status box that displays record duration data, pre-trigger data, the number of kilosamples to be captured, the number of records on the AstroDAQ hard disk, and the amount of available space on the AstroDAQ disk. The status box is dynamic and changes to reflect the selected settings of the data-capture parameters.



Triggering data captures

Generally, AstroDAQ data acquisition begins when the system is armed. Arming the system begins the pre-trigger phase during which samples are acquired and stored up to a pre-set amount. When the pre-set amount of data has been stored, the oldest sample is replaced by the most recent creating a circular buffer.

This continues until a valid trigger is detected and the post-trigger phase begins. In the post-trigger phase, data is acquired and stored until the user-specified amount of samples is collected or the capture is aborted.

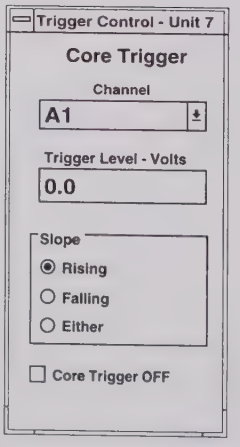
Core trigger

AstroDAQ provides the ability to respond to the following triggers:

- external triggers through the UTILITY port
- manual triggers using AstroLINK
- triggers created by threshold crossing for a user-specified channel

The threshold trigger is referred to as the core trigger because it is available without adding optional modules. When no accessory module is present, click the *setup waveform triggering* icon to access the Trigger Control dialog box for specifying core trigger conditions.

setup waveform triggering



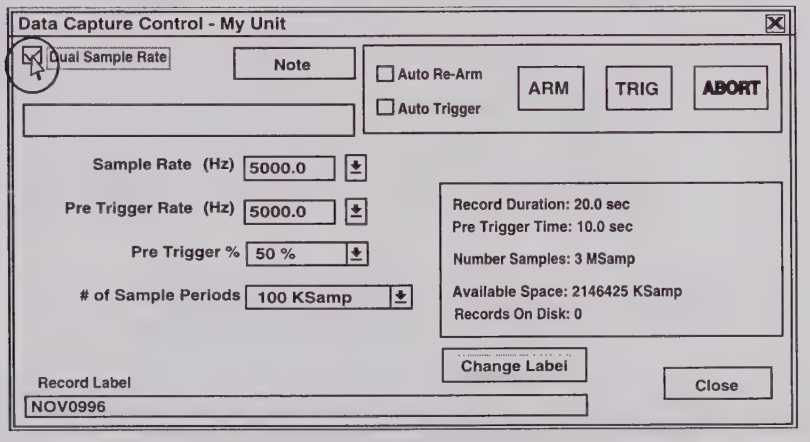
Any active waveform channel can be used as the source of the trigger. The threshold is specified in user engineering units.

AM1 triggering

When the AM1 module is installed, the triggering options available to the AstroDAQ are significantly enhanced. Refer to chapter 11, AM1 accessory module, for further information.

Dual sample rate

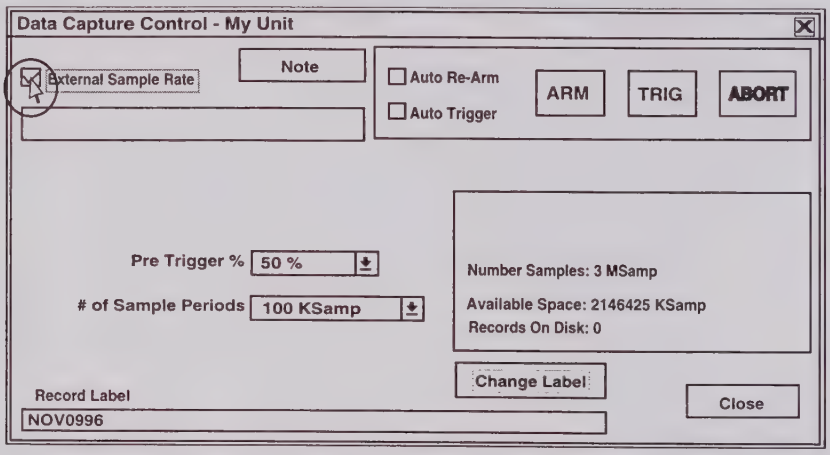
To this point in the discussion of data capture, it has been assumed that the sample rate of the AstroDAQ remains constant during the acquisition. Although this is the most common situation, it is possible to specify one sample rate for the pre-trigger phase and a second sample rate for the post-trigger phase. This is done by selecting the Dual Sample Rate option in the Data Capture Control window.



A typical dual-sample rate application is the case in which a slow sample rate is used before the trigger, but a high sample rate is used to record post-trigger activity.

External sample rate

The external sample rate option allows the data capture sample rate to be controlled by an external clock pulse provided through the AstroDAQ UTILITY port. When an external clock pulse is used, a sample is taken on the rising edge of the clock. The pulse must remain high for at least 300 microseconds. The external sample rate must not exceed 1000 Hz.



Data captures with multiple AstroDAQs

The data capture and other operational settings of each AstroDAQ system on a multiple AstroDAQ network can always be defined completely independently of the other AstroDAQs on the network.

Alternatively, it may be desirable to configure multiple AstroDAQs on a network to use a common trigger to initiate data capture. This is accomplished by cabling the AstroDAQ Systems together. See the UTILITY port connector description in chapter 20, maintenance.

When an AstroDAQ network has been connected in this way, a trigger detected on one AstroDAQ causes the remaining AstroDAQs to trigger virtually simultaneously. Because the trigger point is always marked by AstroDAQ Systems, it becomes acommon reference point for multiple AstroDAQ configurations.

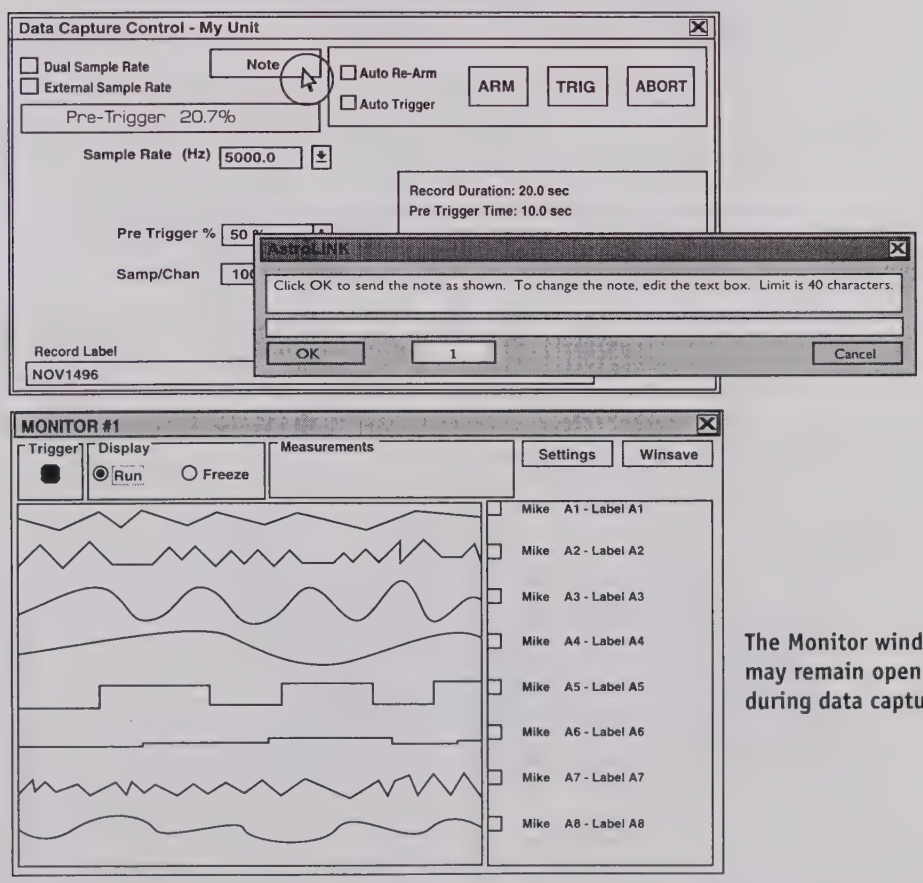
Notes features

The Notes feature provides a convenient way for the user *to take notes before and during a data capture.* This feature is primarily used to tag samples during data capture, but notes can be edited and added in the Record Management utility as described below.

To take notes during a data capture:

1 Click the Data Capture icon to open the Data Capture window.
2 Ensure the system is armed.
3 Click the Note button and make notes as desired in the text box.

Each record can store a maximum of 30 notes, each up to 40 characters long. Any notes taken during the data capture will remain in the record. Notes which are taken during the pre-trigger phase will not be time-tagged due to the constant cycling of the pre-trigger phase.



The Monitor window may remain open during data capture.

Note

If you are entering characters in the note text box during a data capture, the capture status block will appear frozen. However, the capture is active during this time and will reflect its current status when you close the text box.

Reviewing records and related note tags

The record and corresponding note tags can be reviewed using the Record Management tool. If a record contains notes, a summary of those notes will be provided by clicking the Summary button in the Record Management window. The notes will be identified in this format: note #, sample #, note text. The sample number of each note tagged during the pre-trigger phase will be "1."

The Review Setup window contains an Edit Note command which allows editing of existing notes or the entry of new ones. To access the Edit Note command button:

1 In the Record Management window, click the Review button.
2 In Record Review, click the Settings button.
3 In Review Setup, click the Edit Note button.

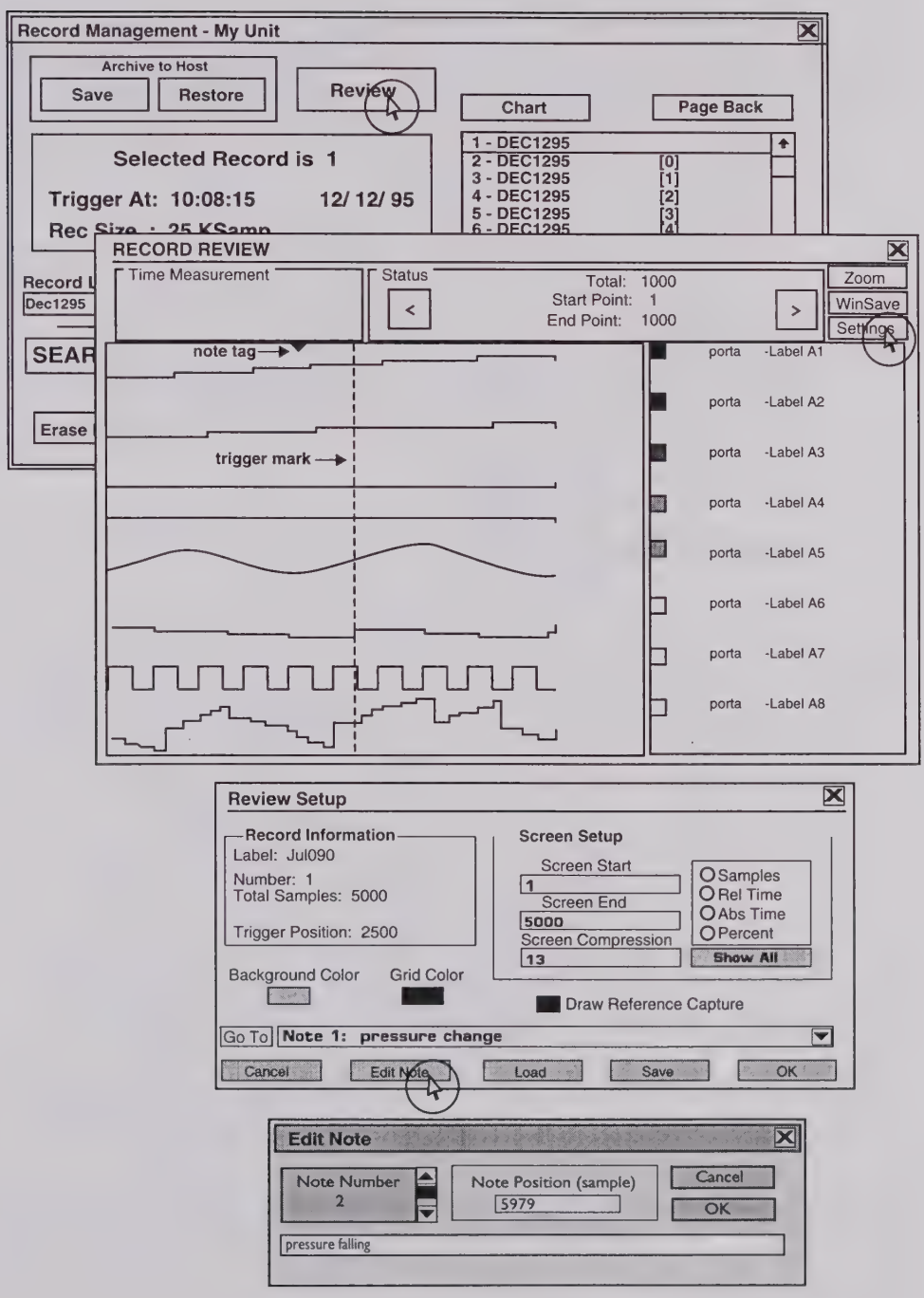
Use the pull-down menu to the right of the Go To button to see a list of notes, markers and triggers associated with the record. Highlight the item you wish to access and then click the Go To button.

The Note Position (sample number) can be modified in the text box.

To add a new note:

1 Click the desired sample position in the Review Record window.
2 Click the Settings button.
3 Click the Edit Note button.
4 Select an unused Note Number (the marked sample position will be identified in the Note Position block).
5 Make the note entry in the text box.
6 Click OK.

The Markers feature, described in "Markers feature" in chapter 14, provides a convenient way to make time measurements when reviewing data-capture records within the record management function.


Record Management - My Unit
Archive to Host
Save
Restore
Review
Chart
Page Back
Selected Record is 1
Trigger At: 10:08:15 12/ 12/ 95
1 - DEC1295
2 - DEC1295 [0]
3 - DEC1295 [1]
4 - DEC1295 [2]
5 - DEC1295 [3]
6 - DEC1295 [4]
RECORD REVIEW
Time Measurement
Status
Total: 1000
Start Point: 1
End Point: 1000
Zoom
WinSave
Settings
note tag
trigger mark
porta -Label A1
porta -Label A2
porta -Label A3
porta -Label A4
porta -Label A5
porta -Label A6
porta -Label A7
porta -Label A8
Review Setup
Record Information
Label: Jul090
Number: 1
Total Samples: 5000
Trigger Position: 2500
Screen Setup
Screen Start
1
Screen End
5000
Screen Compression
13
Samples
Rel Time
Abs Time
Percent
Show All
Background Color
Grid Color
Draw Reference Capture
Go To
Note 1: pressure change
Cancel
Edit Note
Load
Save
OK
Edit Note
Note Number
2
Note Position (sample)
5979
Cancel
OK
pressure falling

Data capture with the host computer disconnected

Although AstroDAQs cannot be controlled without the use of a host computer, they can be configured to perform data captures while disconnected from the host. To accomplish this:

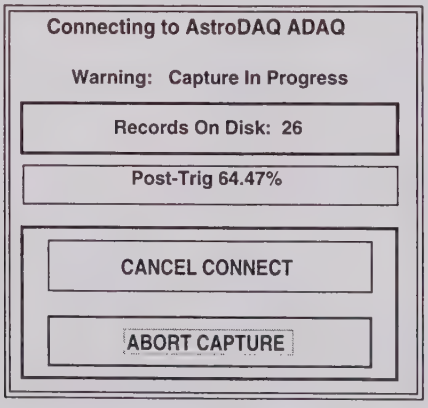
1 Configure the desired data capture session from the host.
2 Close AstroLINK and physically disconnect the AstroDAQ from the host.

The disconnected AstroDAQ will continue to perform its data capture and trigger functions.

The AstroDAQ contains a built-in uninterruptable power source (UPS), which will protect data and system settings when the unit suffers a power loss. The AstroDAQ will perform an orderly shut-down of system functions when its built-in power supply approaches exhaustion.

An external accessory that plugs into the disconnected AstroDAQ and indicates ongoing data-capture activity is available. Contact Astro-Med Technical Support.

Retrieving data from an AstroDAQ that has been disconnected from its host requires reconnection of the AstroDAQ to the host. After the host and AstroDAQ have been reconnected, AstroLINK should be able to establish a connection. If a data capture is in progress, the connection cannot proceed and the menu shown below is displayed. The capture can be allowed to complete or can be aborted.

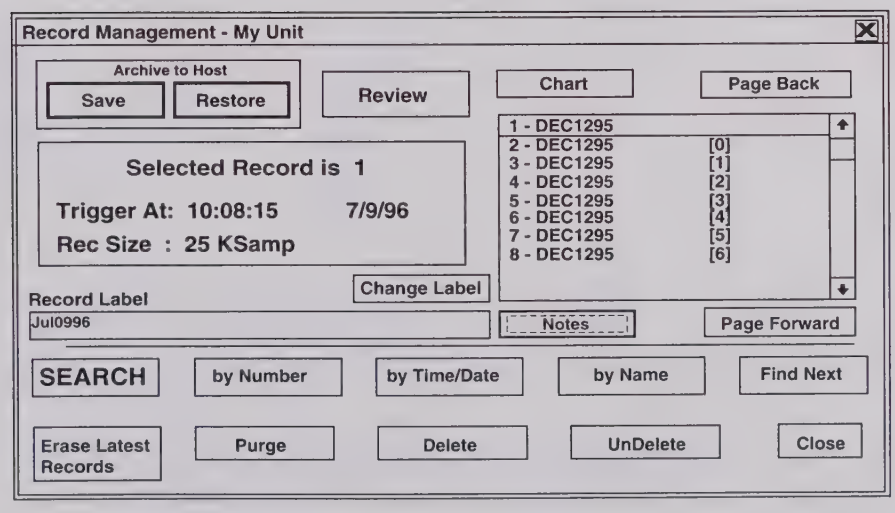


If AstroLINK cannot connect to the AstroDAQ, press the CLEAR button on the AstroDAQ and hold it for two to three seconds. The connection process should then be repeated.

14 RECORD MANAGEMENT

The AstroDAQ's data-capture record management tools include: record review, print record, record search, and record maintenance. These tools are available through the Record Management window discussed in this chapter.

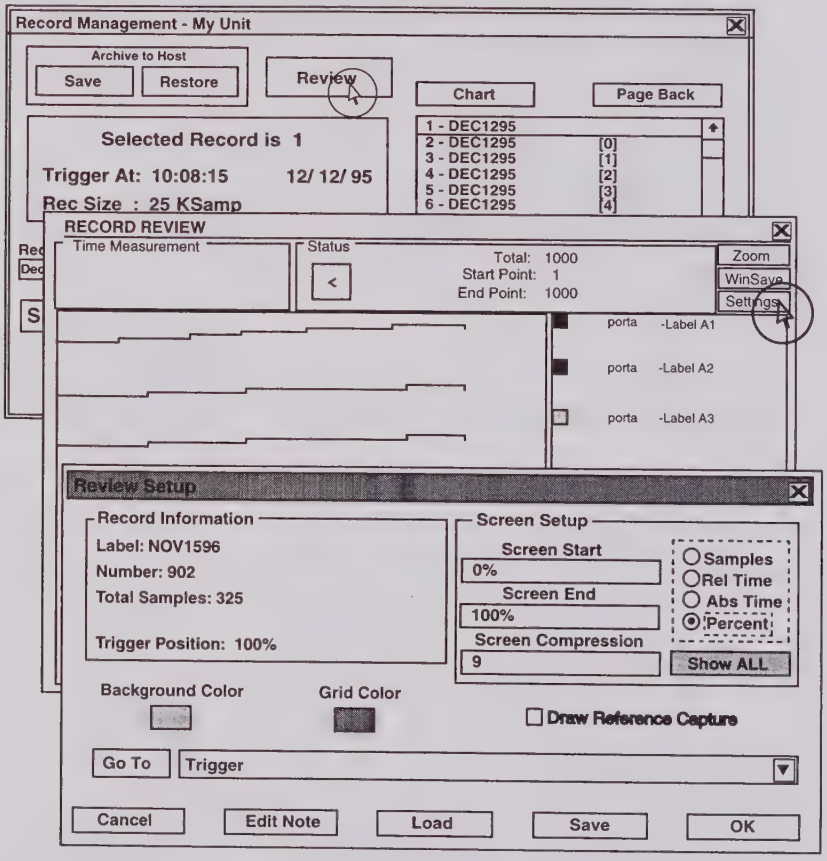
Click the *Disk Utility with Search and Review* icon to open the Record Management window.



The Record Management window provides the controls used to view, print, and manage data-capture records, as described on the following pages.

Record review

The powerful Record Review function (window shown below) presents an oscilloscope-like view of the selected data-capture record.



The Settings command in the Record Review window provides the following screen setup options:

1 **Samples** presents the sample number at the point of the mark.

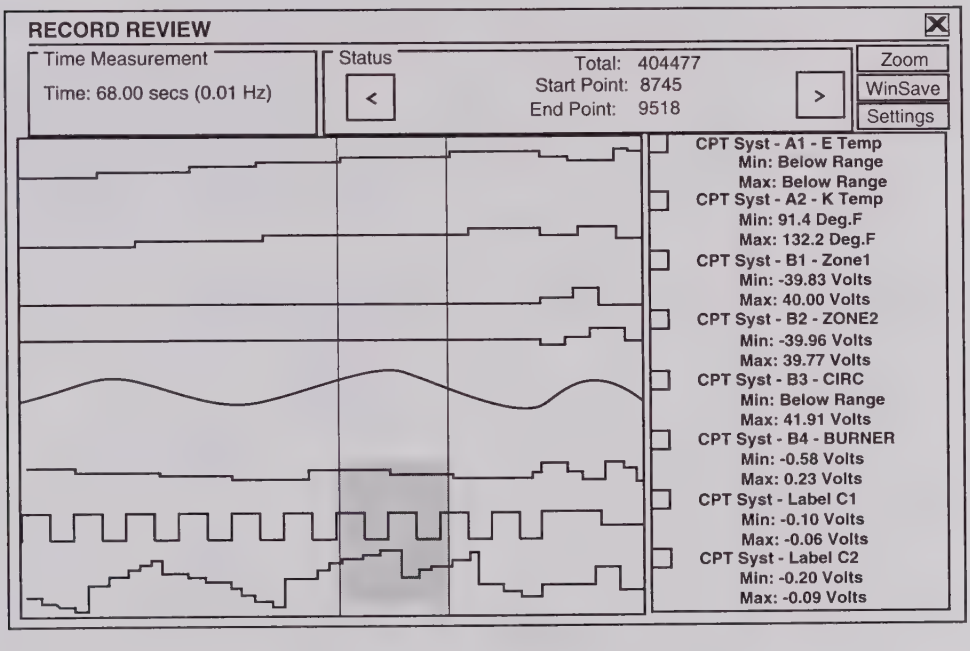
2 **Relative Time** is related to the trigger: a negative value represents pre-trigger data; a positive value represents post-trigger data.

3 **Absolute Time** is the actual time the sample occurred; a reading in absolute time is permitted on records of a 30-second duration or longer.

4 **Percent** represents a percent of the total record.

The Record Review function provides the capacity to *quantify* displayed waveforms. To quantify waveform data after a capture is complete:

1 Hold the left mouse button down and drag the mouse over a section of the waveform.
2 Release the mouse button to display the value of all displayed signals in user engineering units (shown at right side of the window below).



The quantified data presented in this window shows:

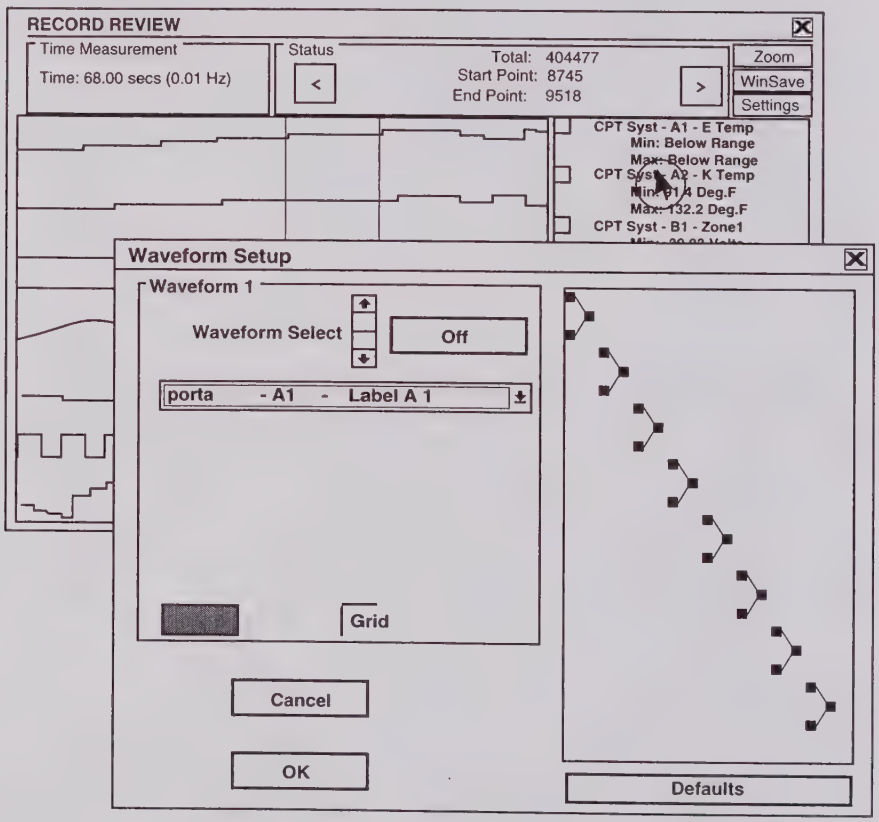
- the minimum and maximum signal values over the period of time specified
- the time period selected (upper left block of the window)
  - the inverse of the time period displayed as Hz (useful only if the selected area represents a signal cycle)

The long vertical lines indicate the time period selected. The highlighted box represents the area that will be expanded if ZOOM is selected.

The format of the display can be changed at any time. To change the display:

1 Place the cursor over any of the channel text fields at the right side of the window.
2 Click the left mouse button.

The Waveform Setup window, shown below, will appear.



In the Waveform Setup window, the graphic display on the right is used to change the physical size and location of the displayed waveforms. *Changes are made by clicking and dragging on the waveform anchor blocks.*

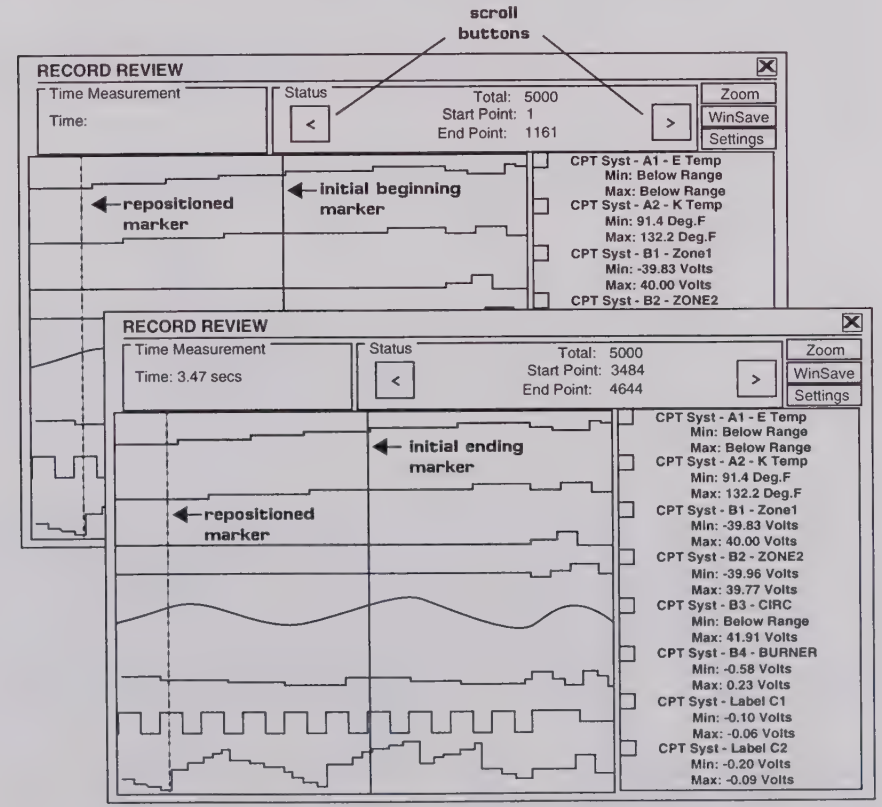
Generally, the waveforms are color-coded to simplify waveform identification. The colors used for the waveforms are user-selectable. The ability to specify the color scheme of choice is a feature common to all AstroDAQ waveform displays.

Markers feature

The Record Review function includes a convenient feature for making time measurements on records which span several screens on the display. The markers can be placed anywhere in the record. Markers are not available while an area is zoomed or a time/zoom area is active.

To enable the markers feature for time measurement:

1 Open the record and use the scroll buttons to find the display area where the starting point will be marked.
2 Enter CTRL 1 on the keyboard. (A marker will appear in the center of the display.)
3 Using CTRL and the right or left arrow buttons on the keyboard, reposition the marker to the desired start point.
4 Use the right scroll button to find the display where the ending point will be marked.
5 Enter CTRL 2 on the keyboard. (A marker will appear in the center of the display.)
6 Using CTRL and the right or left arrow buttons on the keyboard, reposition the marker to the desired end point.
7 To clear a marker, press CTRL F8.



Each marker is associated with a sample number, so the marker position will remain fixed if the compression is changed. The marker position is changed by one pixel on the screen, not by one sample. One pixel on the screen is the compression number of samples.

To use the Go to Marks command in the Settings window:

1 Select Marks in the list box near the Go To button.
2 Use the screen compression text box in the upper right area of the window to define screen compression.
3 Click the Go To button.

By activating the Go to Marks command, the start of the screen will be set to the first mark (lowest sample number) and will adjust the compression so the second mark appears as close to the end of the screen as possible.

When a new mark is initiated, all previous marks are deleted.

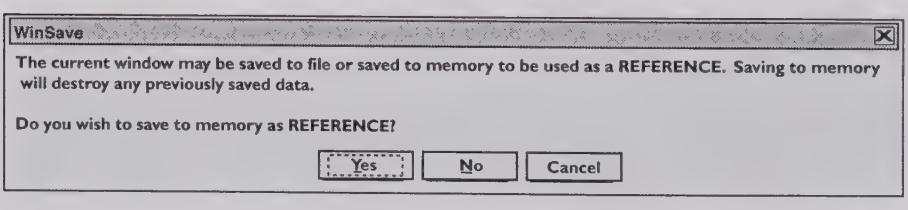
Reference capture feature

The Record Review function includes the capability to draw a reference capture and use it for comparison purposes. The reference can be compared either to a sample within the record or to a sample within another record.

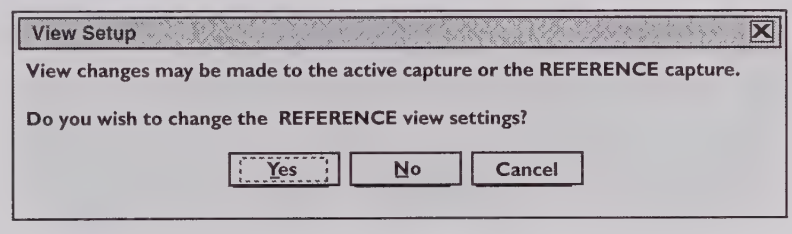
The reference capture feature is available in both the Scope tool and the Record Management tool (within Record Review). Its operation is identical in both cases.

To create (draw) a reference:

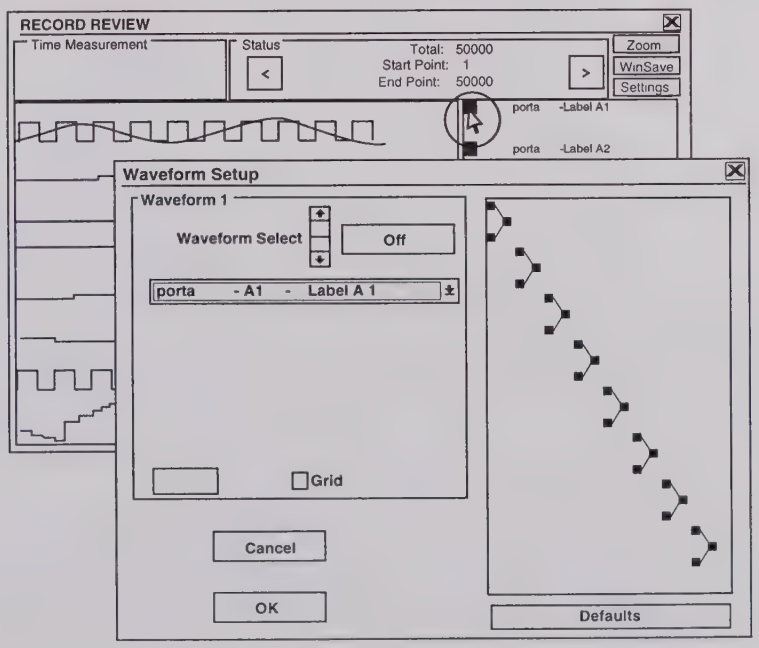
1 In Record Review or Scope, mark a section of the desired reference sample.
2 Click the WINSAVE button in the upper right corner.
3 Select YES in the WinSave window; the reference will be stored in temporary memory and will be lost when you exit AstroLINK.
   - If you select No, the sample will be not be saved as a reference; a screen will appear with file save options.


WinSave
The current window may be saved to file or saved to memory to be used as a REFERENCE. Saving to memory will destroy any previously saved data.
Do you wish to save to memory as REFERENCE?
Yes
No
Cancel

4 Open the record and locate the sample area which you wish to compare with the reference sample. (Or locate the sample area of the same record, if desired.)
5 Click the Settings button.
6 Click the Draw Reference Capture box to select it.
7 To modify the waveforms display, click the channel label at the right side of the screen. The View Setup screen (shown below) will appear.
8 Click Yes if you wish to change the reference settings.
   • The Waveform Setup window will appear.
9 Select the desired channel from the pull-down channel label menu.
10 Click the colored rectangle at the lower left of the screen.
11 In the Monitor Color Setup window, click a color option. Click OK.
   • Turn off channels that you don't wish to view.
12 Click OK in the Waveform Setup window.


View Setup
View changes may be made to the active capture or the REFERENCE capture.
Do you wish to change the REFERENCE view settings?
Yes
No
Cancel

Once drawn, the reference sample will appear in any record you review. It will remain until you either click the "Draw Reference Capture" box to remove it or you exit AstroLINK. For further information on WinSave, refer to "Saving waveforms on the host disk" in chapter 15.



Record playback

Record playback means to print a hard copy of a chart recording that was stored as a data-capture record.

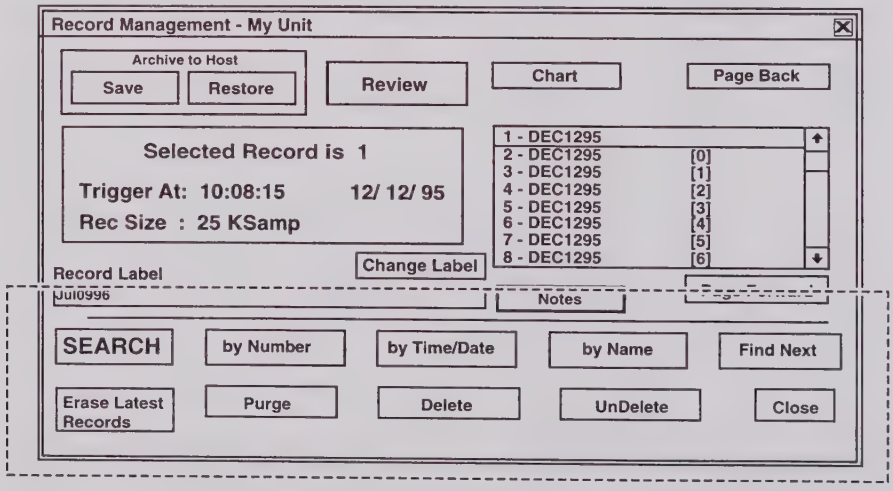
When the Chart button in the Record Management window is selected, the Print Record/Chart Recorder window appears. This window is used to set up the hard-copy printing of data-capture records on an AstroGRAPH chart recorder. If no AstroGRAPH is attached to the AstroDAQ, AstroLINK's printing setups will not apply.

Parameters available from the Print Record/Chart Recorder window include: selecting a record for playback; specifying the desired portion of the selected record for playback; selecting a chart style; selecting a playback time base; and reviewing the details of the playback setup.

Refer to the *AstroGRAPH User Guide* for complete information.

Record maintenance

The Record Management window includes the data-capture record maintenance functions described below and on the following page.



To search for a record, click the Search button and then select the type of search: by number, time/date, name or next record.

To mark a data-capture record for deletion, select the record in the record identification area of the window, then click the Delete button. To delete the record, click the Purge button. Remaining records are sequentially stacked adjacent to one another on the AstroDAQ hard disk.

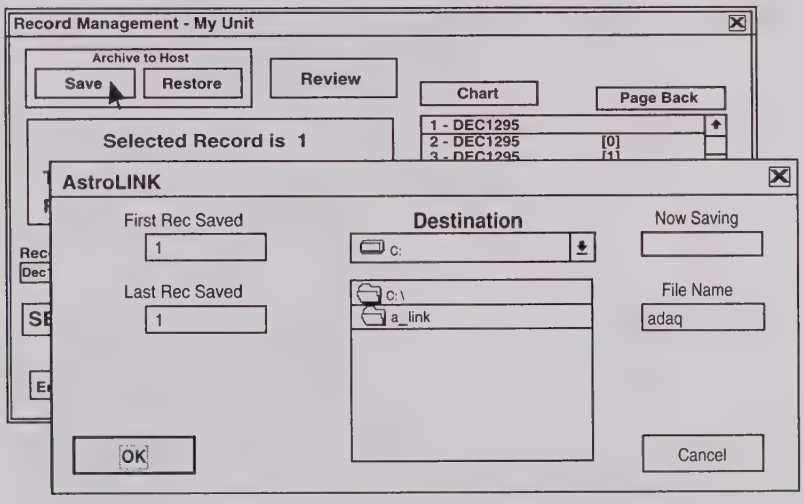
Because records must be sequentially stacked adjacent to one another, purging can be a time-consuming process if many records are involved. The Erase Latest Records button deletes the last several records captured and frees some hard disk space potentially much more quickly than the Purge function.

Archive to host

The Archive to Host feature (upper left area of the Record Management window) is used to:

- save AstroDAQ records on the host PC in binary format
- restore records on any AstroDAQ with sufficient disk space (when restored, a record can be reviewed as if it had just been acquired)

The following window appears when the Save button is selected.



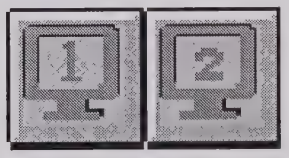
Only complete records can be archived, but multiple records can be saved without user intervention. AstroLINK automatically adds a record number to the selected file name. For example, if records 4 through 9 are archived using the name "Test," the first file will be named "Test4.dcr" and the last file will be named "Test9.dcr." *Only the first four characters of the file name can be user-specified*, because the record number may require three digits.

When multiple records are archived, any records marked as deleted will be ignored.

15 MONITORING REAL-TIME WAVEFORMS

Although the AstroDAQ system is primarily intended for data acquisition, the system provides a comprehensive set of functions to monitor signal activity independent of the data acquisition process. These functions are available by accessing one or both of the two Monitor windows.

Click the *Monitor* icon to open the Monitor window. Generally, both windows can be used at the same time.

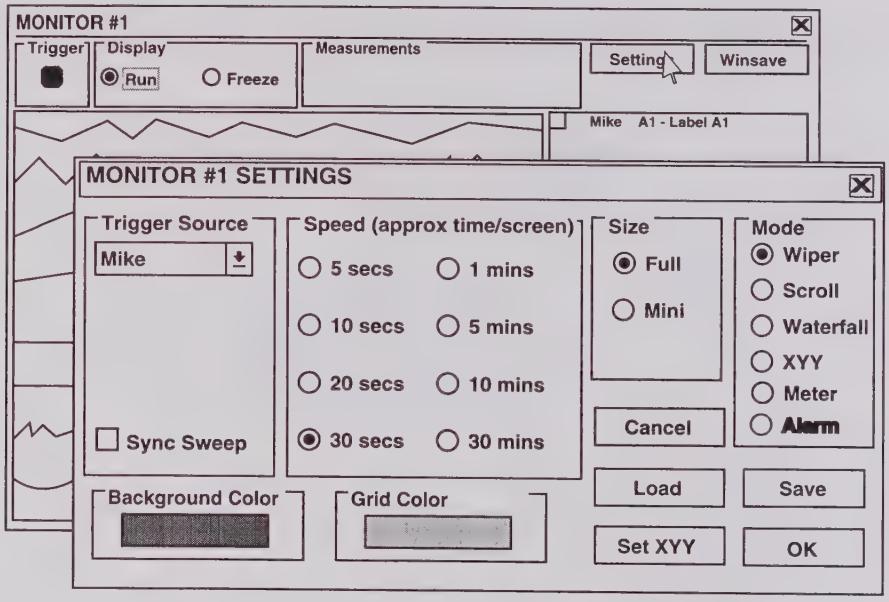


Monitor 1

Monitor 2

Setting up the monitor window

Select the Settings button in the Monitor window to access the monitor's setting options as shown below. Selections made in the Settings dialog box are implemented when the OK button is clicked.



The Mode options provide five display format options which are described on the following pages. A sixth format, Alarm, is available only through Monitor 1. When the Alarm format is used, Monitor 2 is still available for use. The Alarm format is associated with accessory modules and is described in chapter 11.

After a mode has been established, you can save the format to a PC disk file by clicking the Save button. Files containing monitor format information are referred to as view files and should include the suffix ".amv". Information contained in view files includes:

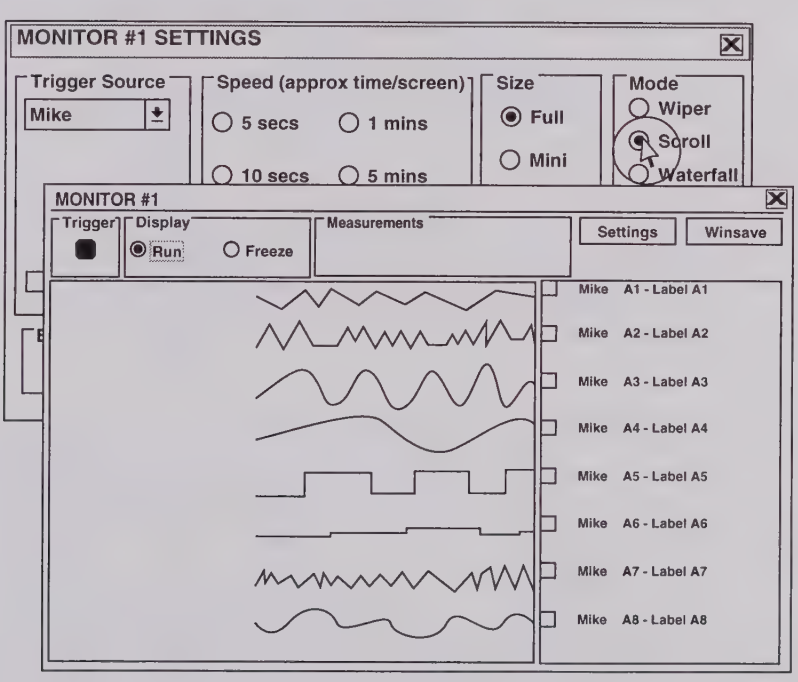
- channels to be monitored
- display colors
- sweep speed
- monitor format
- size and location of waveforms
- trigger display source

To recall a View file, select the Load button in the Settings dialog box. View files can also be recalled along with other setup files as part of a test set; see chapter 16, Make Test utilities.

Selecting a waveform monitor format

The Mode options provide five monitor formats. The following three waveform monitor formats provide a real-time display of a maximum of eight waveforms in each Monitor window:

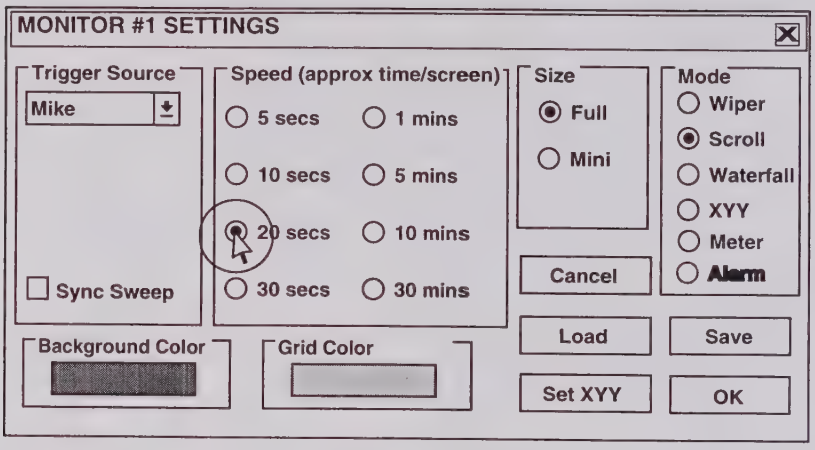
1 WIPER - the waveform is displayed from left to right with the oldest part of the waveform at the right side of the display.
2 SCROLL - the waveform is displayed from right to left with the oldest part of the waveform at the left side of the display.
3 WATERFALL - the waveform is displayed vertically with the oldest part of the waveform at the bottom of the display.



Monitor 1 and Monitor 2 can be opened at the same time, providing a total display capability of sixteen waveforms.

The Size options permit each monitor to be independently adjusted as "full" (approximately full screen on VGA displays) or "mini." When Monitor 1 and Monitor 2 are being used at the same time, it is possible to force one of the monitors to remain in the top position on the screen. Use the Options pull-down menu in the main AstroLINK window to activate this feature.

Sweep speed and time-base resolution



Sweep speed is specified in terms of the time needed to sweep once across the display. The actual speed in mm/sec depends on the physical display size. The fastest available speed setting is 5 seconds per screen. This corresponds to 25-30 mm/sec on a typical display. Not all computers can achieve this sweep speed reliably because the speed is dependent on both the speed of the host processor and the installed video card.

The AstroDAQ is designed to stack display segments to compensate for short periods of time when the processor is busy. The segments are sent in a burst when the processor becomes available to enable the display to "catch up," leaving an accurate time base on the monitor. If "catch up" occurs frequently, a slower sweep speed should be used.

A special characteristic of the Monitor window is that it provides a full bandwidth representation of the signal, regardless of the sweep speed. This is because bandwidth is determined by the AstroDAQ sample rate, which is constant and independent of the host computer. The monitor's time-base resolution does depend on sweep speed.

If it is necessary to obtain more time-base resolution than is available with the Monitor function, the Scope function can be used. Scope provides a display that looks identical to Monitor, but is not real-time. Scope time-base resolution is potentially much higher than Monitor, because it is not restricted by the display capabilities of the host. See chapter 3 for further information on the Scope function.

Each AstroDAQ generates waveform segments for the Monitor at a fixed rate. If both Monitors are displaying waveforms from the same AstroDAQ, they are forced to run at the same sweep speed. Channels from different AstroDAQs can be displayed on the same monitor.

Comparing waveform monitor to scope and review

The following is a comparison of the three AstroLINK displays (under the Record Management tool). Each of these displays show eight color waveforms as functions of time and use the Waveform Setup window to select channels and adjust waveform size and position. Differences between displays result from the manner in which each window gets information from the AstroDAQ. The mechanisms used by each display are discussed below.

Display	Mechanism
Waveform Monitor	receives line segments generated by the AstroDAQ at a regular rate determined by the user-specified sweep speed. The line segment for a particular channel is determined by the minimum and maximum amplitude of the waveform since the previous line segment.
Scope	receives point data collected by the AstroDAQ and saved temporarily in AstroDAQ memory. This memory is volatile and is reused for every Scope capture. The time between each point is determined by the user-specified sample rate. The Scope function creates the display by drawing lines between the points.
Record Review	receives line segments generated by the AstroDAQ from samples collected by the AstroDAQ during a previous data capture. Data Capture stores waveform samples on the AstroDAQ hard disk at a user-specified sample rate. The time represented by each line segment depends on how much the waveform must be compressed to fit on the display. This is user-specified.

Below is a description of features affected by the differences between AstroLINK display types.

- Waveform Monitor preserves the full bandwidth of the AstroDAQ, independent of the sweep rate. This results from the fact that Waveform Monitor receives data from the AstroDAQ as line segments (min/max pairs) that are created in the AstroDAQ and are always based on a 5-kHz sample rate.

  The bandwidth of the Scope and Record Review functions depends on the user-specified sample rate. This implies that if filters are not set correctly by the user, aliasing may occur.

- Because it works with line segments that can become distorted if expanded, Waveform Monitor does not provide a Zoom feature.

  Scope implements Zoom by interpolating between sample points. Review implements Zoom by changing the compression factor and, therefore, the time base. If the review compression factor is 1, then Review will interpolate like Scope. In Review, a compression of 1 receives point data just like Scope.

- Waveform Monitor can send a frozen display to the host as an ASCII file. To make it compatible with popular post-processing software, this ASCII file provides a single value for every point in time along the selected portion of the display. Because a Waveform Monitor display consists of line segments, each segment must be converted from a minimum/maximum pair to a single value. The user can choose to save either the minimum, maximum, or average of minimum/maximum (midpoint) values.

  Scope has only single-point data and can only save the original samples. Record Review, like Waveform Monitor, has line segments representing the present level of compression but can also request the original samples from the AstroDAQ because the samples are saved to disk. As a result, the Record Review function offers a full set of choices for saving the display.

Making measurements with waveform monitor

The Monitor window includes the following Display options: Run and Freeze. When Freeze is selected, the sweep stops and the time base is aligned so that the oldest part of the waveform is at the side of the screen which it occupied during Run. Measurements of waveform amplitude and time can be made using the cursor tools discussed under "Scope tool" in chapter 3.

NOTE: *Be sure to re-select Run after using the Freeze option. Failing to unfreeze the display will cause the appearance of a problem.*

The Trigger Source options box in the Monitor window includes a sync sweep option. When a given signal input generates a regular and repetitive cycle which you wish to position near the center of the display area, this option can be selected.

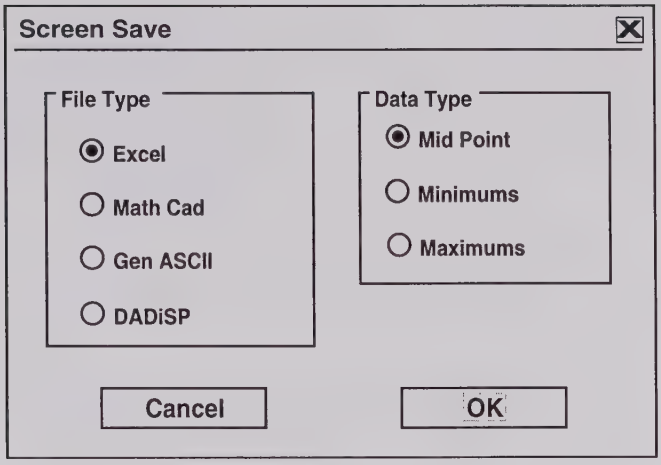
Saving waveforms on the host disk

To save a display as an ASCII file on the host disk:

1 In the Monitor window, select Freeze as the Display option.*
2 Click the WinSave button.
3 In the Screen Save menu (shown at top of next page), select the desired File Type and Data Type options.

*To save a portion of the display (time measurement), freeze the display, then place the cursor at the beginning of the waveform area to be selected, hold down the left mouse button and drag it over the area to be marked. Continue with Step 2.

NOTE: *If an area of the waveform is marked (time measurement), only that area will be saved to disk. If no area of the display is marked, the entire display will be saved.*



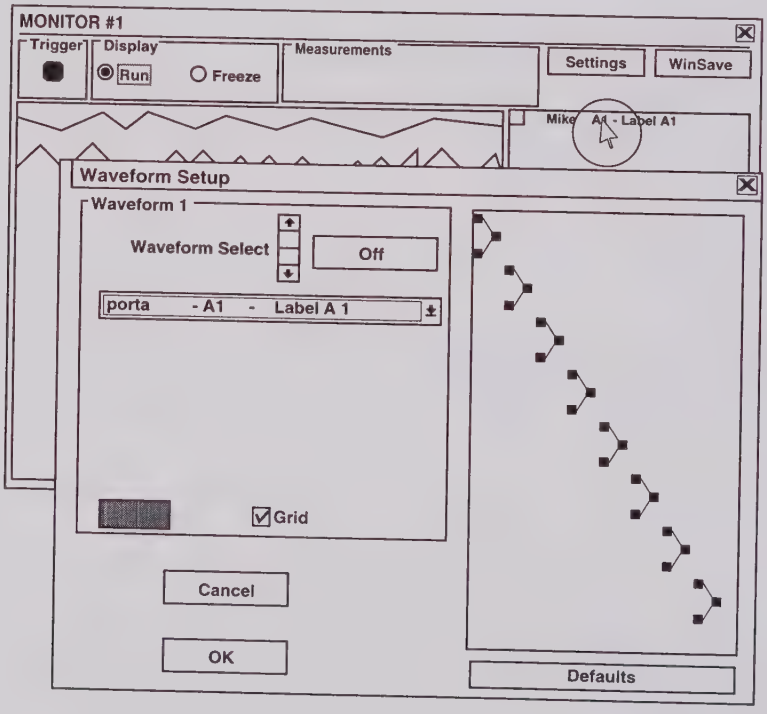
The ASCII file provides a single value for every point in time along the selected portion of the display. This requires that each line segment making up the frozen display be converted to a single value. The user can choose to save either the minimum, maximum, or midpoint values of the line segment. Several ASCII formats are available. All are readable with most text editors.

Using the waveform setup window

To bring up the Waveform Setup window (shown below), click a channel label or color block at the right side of the Monitor window. The Waveform Setup window is used when in wiper, scroll, waterfall or meter mode in order to:

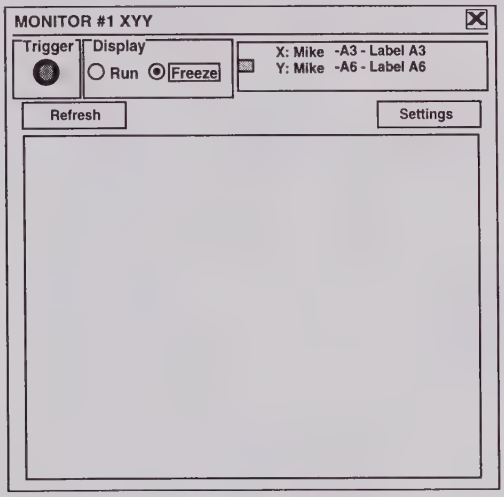
- select the waveforms to be monitored
- assign colors
- arrange the size and relative position of each waveform
- enable upper and lower limit marks for each waveform (grid)

Changes are made to the position and size of displayed waveforms by clicking and dragging the waveform anchor blocks (colored squares) on the right side of the window. The Waveform Setup window is identical to those used by the Scope and Record Review waveform displays.

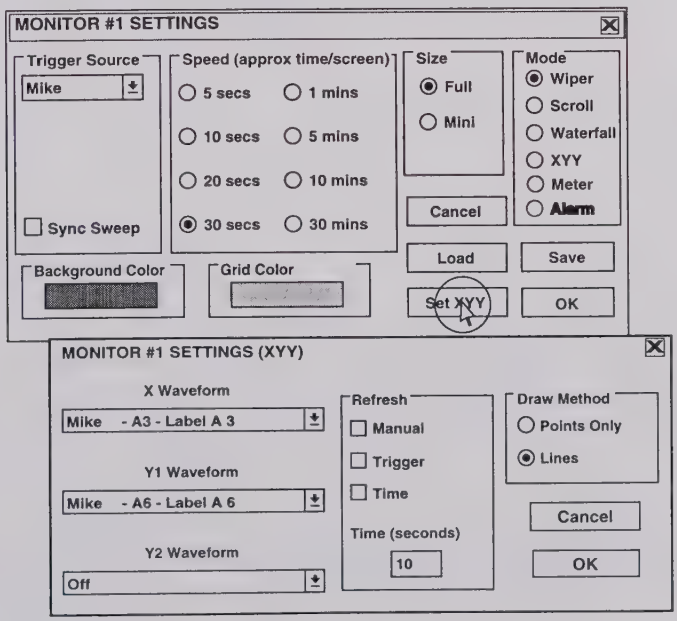


Selecting X-Y plot format

The X-Y plot format is similar to the waveform monitor formats except for the appearance of the display.

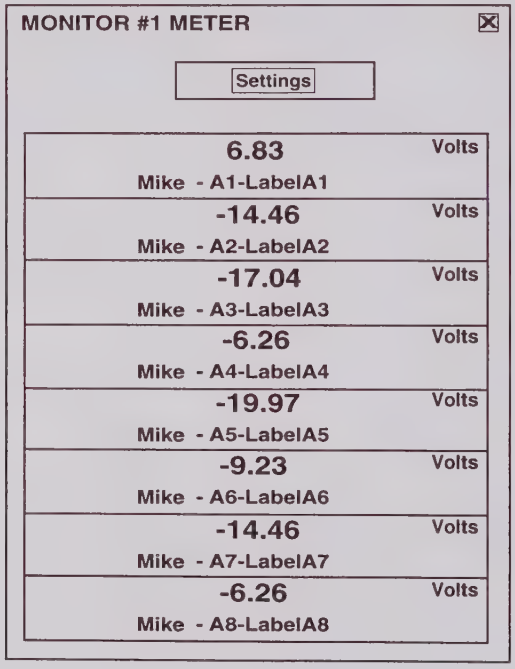


The XYY Settings window is used to specify the waveforms to be displayed, the plot refresh method, and the style of drawing. To access this window, click the XYY mode option in the Monitor Settings window. As with other monitor formats, display settings can be saved to a view file for later recall.



Selecting meter format

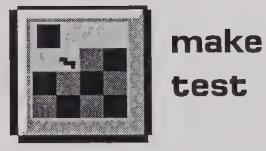
The meter format provides a meter-like numerical display of up to eight waveforms. Values are expressed in user engineering units.

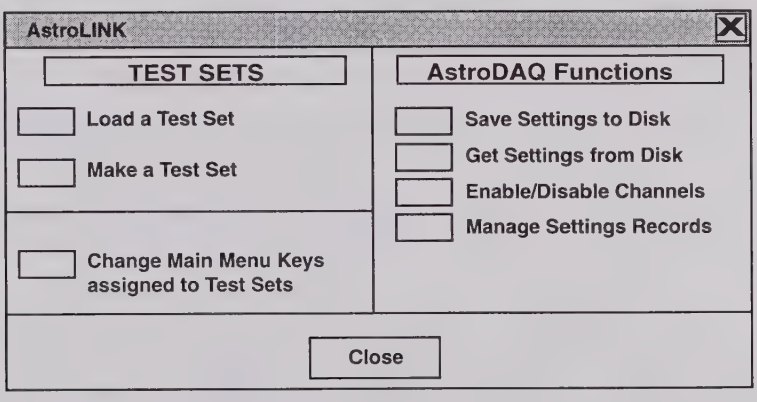


16 MAKE TEST UTILITIES

Make Test is a collection of utilities used to customize AstroLINK and associated AstroDAQs to suit particular test applications.

Click the *Make Test* icon to open the Make Test window (shown below).





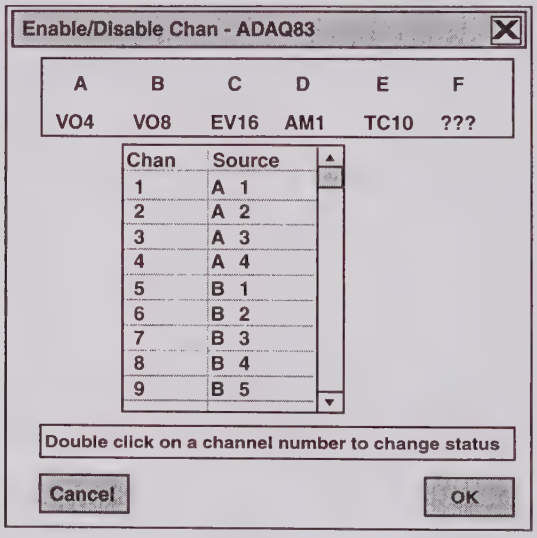
The Make Test window is divided into functions affecting individual AstroDAQs and functions used to design Test Sets. Test Sets may involve one or more AstroDAQs.

The AstroDAQ functions called Save Settings and Get Settings are identical to the functions "Save AstroDAQ Settings" and "Load AstroDAQ Settings" available through the AstroLINK main menu. They are duplicated in the Make Test window as a convenience. Save Settings saves the current settings of a single AstroDAQ to an ".ams" file selected by the user. Settings include parameters such as module gain, filter values, trigger setup, and sample rates.

The function called Enable/Disable Channels allows a user to alter AstroDAQ parameters that cannot be changed at other times. These are usually parameters that would disrupt the test process, such as enabling or disabling channels.

Adding and deleting channels

The Enable/Disable Channels window (shown below) is used to add or delete channels. Click the Enable/Disable Channels selection in the Make Test window to access this window. In the example shown, slot F is empty and all other slots are occupied by a module.



To appreciate the impact of this process, it is useful to review the information provided in earlier sections of this document on the flow of waveform data through the AstroDAQ.

The state of a channel (enable/disable) is changed by double-clicking the channel number column. If the column is holding a number, the number is replaced by a dash (-). If the channel is holding a dash (indicating it is turned off), the dash is replaced by a channel number. *If thirty channels are already enabled, AstroLINK will not allow another channel to be enabled.*

When a channel is enabled or disabled, all higher channel numbers are modified automatically by AstroLINK and reflected in the display. The renumbering does not affect module settings or channel labels. However, it does affect some trigger assignments. In particular, the channel used by the AstroDAQ Core Trigger is determined by a user-specified channel number. If triggers are being used, it is necessary to ensure that trigger settings are verified after enabling or disabling channels.

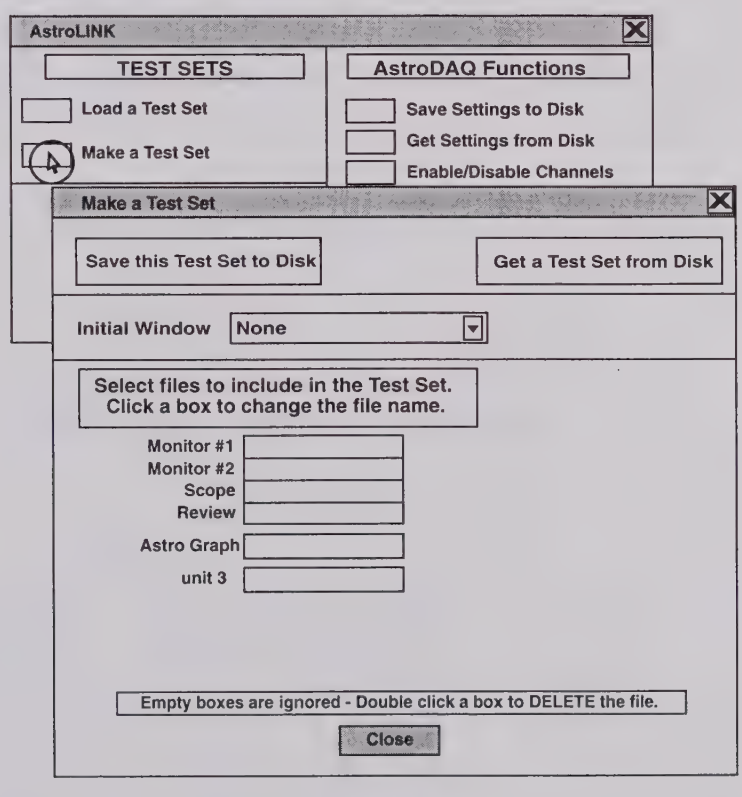
WARNING: Channel renumbering only affects channels higher than the channel being enabled or disabled. If the channels associated with a particular module will be turned on and off frequently, install that module in the F slot to ensure that other channels are not affected.

AstroLINK test sets

An AstroLINK test set is primarily a collection of files that define parameters for AstroLINK and AstroDAQs used during a particular test process.

- Do not confuse AstroLINK test sets with AstroLINK sequences. The Test Set is used only to initialize parameters, after which AstroLINK must be operated manually, as usual.

The contents of a test set are summarized in the window shown below, which appears after clicking the Make a Test Set option in the Make Test window when only one AstroDAQ is connected.



If additional AstroDAQs were connected when this window was opened, there would be one more rectangle for each additional AstroDAQ.

The window shown above is empty and is only useful as a starting point. A Test Set is made by filling in boxes. Rather than starting with an empty set, it is possible to retrieve an existing Test Set by clicking the "Get a Test Set from Disk" button.

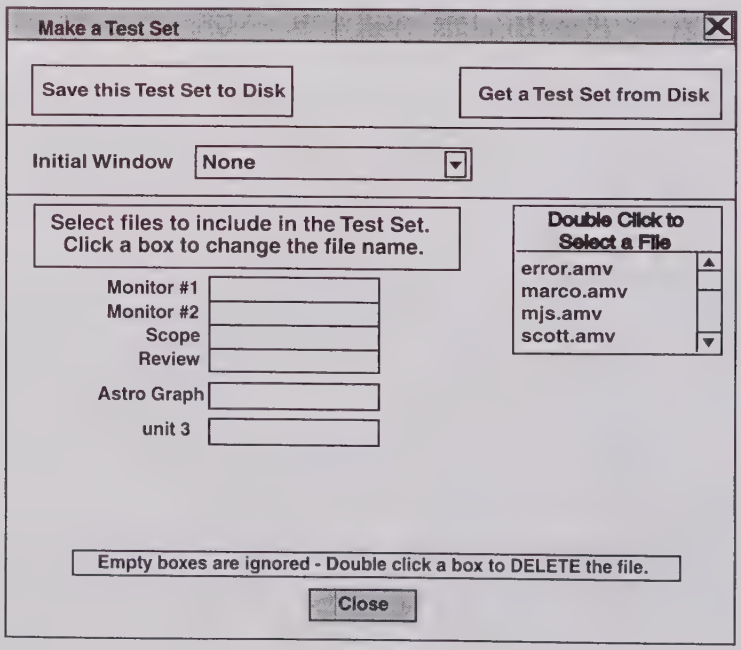
Completed Test Sets must be saved to the host PC by clicking the "Save this Test Set to Disk" button. The test set can then be loaded manually from the Make Test menu or can be associated with a Custom Key as described later in this chapter.

The Initial Window box near the top of the menu provides a pull-down list of Astro-Link windows. Any window can be selected to be opened automatically when the Test Set is run. The most common choices are Monitor and Data Capture. If None is selected, the Test Set will not open any windows when it is run. In any case, it is possible to manually open any AstroLINK window after a Test Set has been loaded.

All other boxes in the menu are used to hold file names. For example, the Monitor 1 box holds the ".amv" file used by the Test Set to initialize Monitor 1. If this box is left empty, the Test Set will not initialize Monitor 1. Instead, the Monitor will open with the standard default settings. Similarly, the boxes Monitor 2, Scope, and Review are intended to hold the names of "*.amv" files, but can be left empty if default settings are acceptable. To speed the loading of a Test Set, as many of the menu boxes as possible should be left empty. Each full box represents a file that must be loaded by AstroLINK.

Clicking a box selects that function to be performed and automatically causes the files with appropriate file types in the User Path to be listed to the right of the box. Double-click the name of the file to be used.

In the example shown below, one of the Monitor boxes has been selected, with the result that only "*.amv" files are displayed in the list.

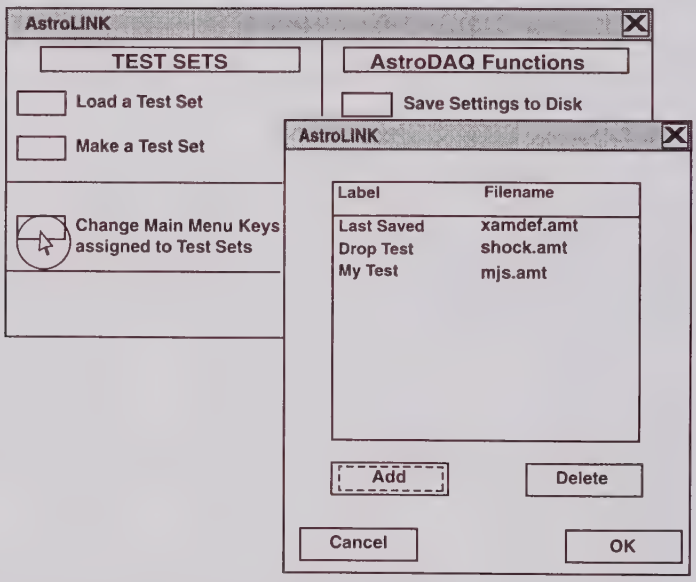


The AstroGRAPH box can contain a single "*.amr" file or can be empty. If multiple AstroGRAPHs are included in the network, the AstroGRAPHs are all initialized to the same *.amr file. Clicking the AstroGRAPH box calls up a list of available *.amr files.

At the end of the list, there is room for ten additional boxes, each of which can hold an *.ams file. The number of boxes shown depends on the number of AstroDAQs that are online when the Test Set is being made. Each box is identified by the label assigned to the AstroDAQ when it was connected. In the example on the previous page, only one AstroDAQ, labeled "unit 3," is online.

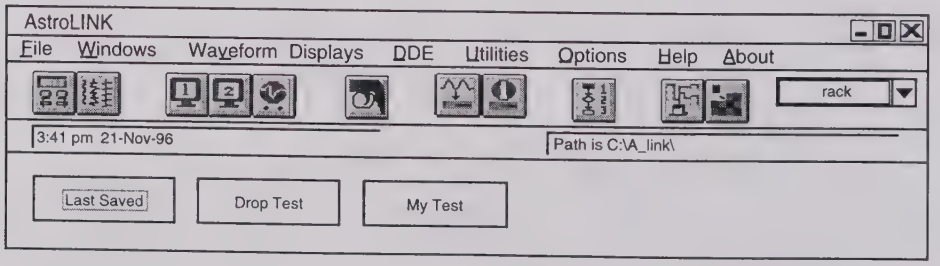
Custom keys

AstroLINK allows a Test Set to be assigned a Key that will appear on the AstroLINK Main Menu. This option is accessed by selecting the Change Main Menu Keys option in the Make Test window as shown below.



In the above example, three Test Sets have been assigned Custom Keys. Each entry includes a user-defined name, which will appear on the Custom Key. The entry also contains the name of the file holding the Test Set. This is the "*.amt" file created when the Test Set was saved; it must be located in the User Path to be used with a Custom Key.

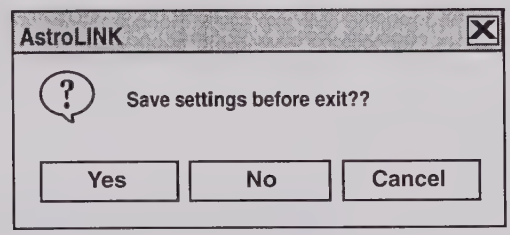
When the Add button is clicked, the user is prompted to choose a file and a key label. Keys are deleted by clicking and highlighting file entries and clicking the Delete button. The list of Custom Keys is kept on the config.amc file. The file is automatically edited as keys are added or deleted. When AstroLINK is launched, it uses the config.amc file to determine the Custom Keys to display. The Custom Key menu shown above would result in the AstroLINK main menu shown below.



Clicking the Drop Test Custom Key causes AstroLINK to load the file "shock.amt" as a Test Set. If the file cannot be located in the User Path, an error message is displayed. Before it completes loading, AstroLINK checks to ensure that the current configuration of AstroDAQs matches the Test Set file. This includes the number of AstroDAQs online and the modules installed in each AstroDAQ.

Restoring previous settings: last saved key

When AstroLINK is exited, the following message is generally displayed.



- Clicking the **Cancel** button cancels the shutdown of AstroLINK.
- Clicking the **No** button immediately closes AstroLINK.
- Clicking the **Yes** button causes AstroLINK to automatically modify the Test Set file "xamdef.amt" that consists of the following files:

xamdefm1.amv	Monitor #1
xamdefms.amv	Scope
xamdefm.amr	AstroGRAPH
xamdefm2.amv	Monitor #2
xamdefr.amv	Review
xamdef1.ams	AstroDAQ settings

If additional AstroDAQs are connected, there will be more .ams files (xamdef2.ams, xamdef3.ams, etc.).

The Test Set file can be loaded manually, using the "Load a Test Set" button in the Make Test utility. To simplify the process of restoring previous settings, the Custom Key labeled Last Saved is automatically created and associated with the xamdef.amt file. This occurs whenever the config.amc file is modified through the Save key in the AstroLINK Configuration window.

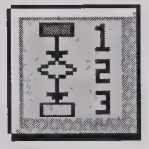
Using the Save key in the Configuration window to save an existing file will clear any Custom Keys. After the Save function is complete, the only key listed in the file is Last Saved. This is easily verified by looking at the config.amc file with an ASCII editor such as Notepad.

17 SEQUENCER WINDOW

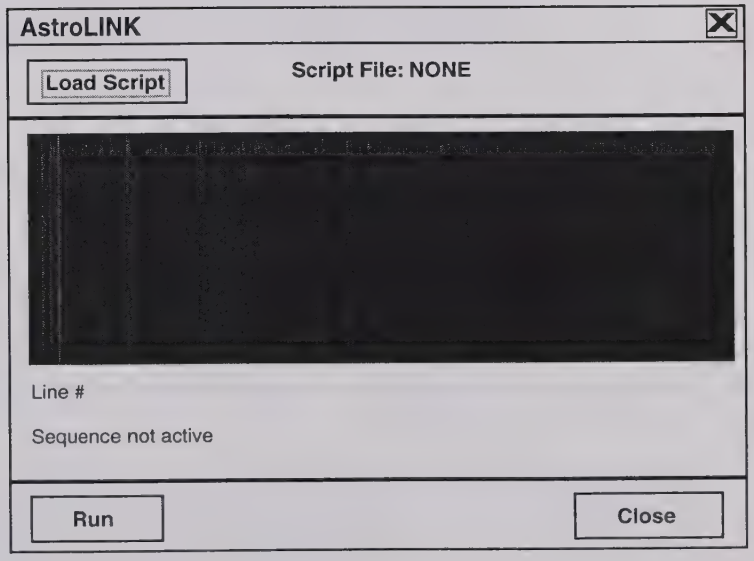
The AstroLINK Sequencer is used to design sequences of AstroLINK operations that can be run without manual intervention. If AstroLINK is connected to one or more AstroDAQs containing accessory modules, the Sequencer can control stimuli such as logic levels, analog voltage levels, relay closures, and the frequency of a pulse train.

Sequences are composed of a set of instructions contained in a sequence file. All sequence files should use the extension "*.amq". Each instruction is a single line of text. The instruction either indicates an action such as "end capture" or causes the sequence to wait for some event such as an AstroDAQ trigger. The instructions are created using a simple scripting language and the Astro-Med sequence generator.

Click the *Sequencer* icon to open the Sequencer window. The initial Sequencer window will look similar to the one shown below.



setup automated sequence

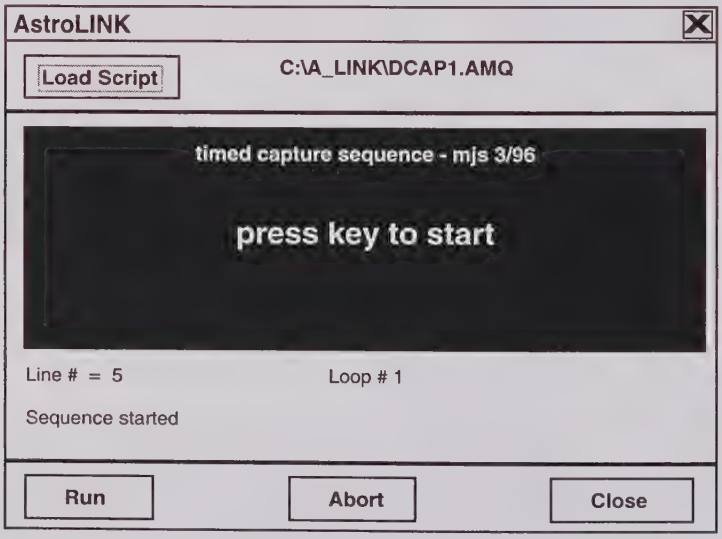


The Sequencer window includes several buttons for operation and a large sequence message field. The window assumes that a sequence has been created and saved in an ASCII file with the extension .amq.

Running a sequence

The first step in running a sequence is to load the file by clicking the Load Script key. This prompts a request for a sequence file. When the file is supplied, an attempt is made to load it. The Load Script function also performs some checks on the sequence and reports any problems found.

When a sequence is properly loaded, a sequence label is displayed at the top of the sequence message field. This label is included in the sequence file when it is created. In the example below, the label is "timed capture sequence - mjs 3/96." The sequence is started by clicking the Run button. This causes the message "Sequence started" to appear below the sequence message field.



The center area of the sequence message field is reserved for user messages, which can be included in the sequence. In the example above, the sequence instruction displays the message "press key to start." User messages always use the larger font. Messages are not required but can help in monitoring the sequence. Some messages are generated automatically.

A sequence can be aborted at any time by clicking the Abort button. This overrides individual sequence instructions. When loaded, a sequence can be executed multiple times without the need to reload the file.

Example sequence

The following is an example of an AstroLINK sequence.

```
[param]
title = "simple message sequence"
environ = "", ""
numlines = "5"

[script]
L1 = "MONITOR", "OPEN"
L2 = "MESSAGE", "press key to start"
L3 = "WAIT", "KEY"
L4 = "MESSAGE", "Finished Sequence"
L5 = "END"
```

The complete script file is divided into two sections. The first section begins with [param] and contains information used by the Sequencer utility. The title line contains the label displayed in the sequence message field whenever a sequence is loaded. The numlines line must contain the number of lines in the script section.

The second section must begin with the line [script]. Script lines follow the [script] header. Each script line must have the form:

LLL = "XXXX"	where LLL is a line label (usually a number) XXX is a script line

The script in this example does the following:

- open the AstroLINK window Monitor 1
- display the message: "press key to start"
- wait for keyboard to be pressed
- display the message: "Finished Sequence"
- end the sequence

AstroLINK sequencer script

The sequencer script is based on a simple structure of keyword followed by modifier. Each keyword can be followed by any one of several modifiers. Modifiers may be followed by one or two parameters. Generally, each line of script is independent and complete.

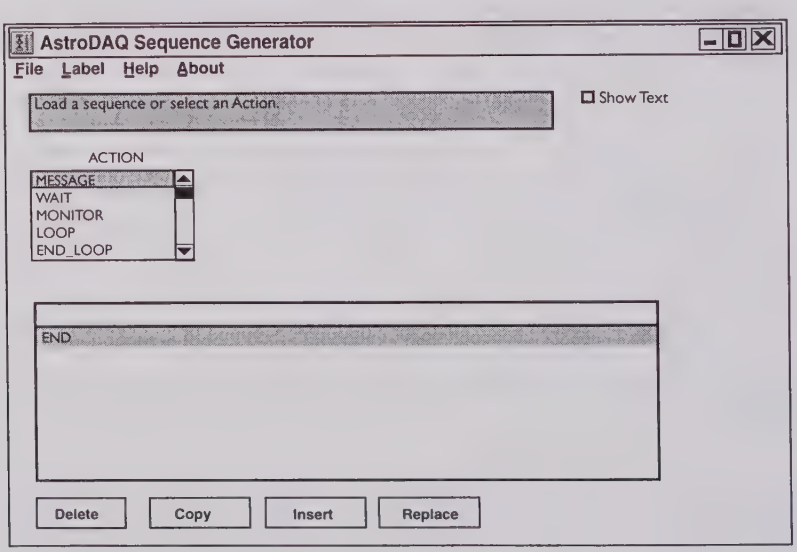
Example sequence lines provided in this section will always begin with LLL =. Note that in the actual script, LLL should be replaced by sequential line numbers. Note also that each element of a script line must be enclosed in quotation marks and separated by a comma. Script elements must always be capitalized.

The term "active AstroDAQ" is used to indicate the AstroDAQ that will receive the instruction. If only one AstroDAQ is online, it is automatically the active AstroDAQ.

AstroLINK sequence generator

The AstroLINK software installer program (see chapter 3) includes an automatic sequence generator utility which provides an off-line program for generating a sequence. The sequence is self-prompting and simplifies the process of developing scripts.

To access the sequence generator in Windows 95, go to Programs > AstroLINK > Sequence Generator.



Sequencer commands

A complete list of commands for the AstroLINK sequencer are provided below. Some of the commands (shown prefixed by an asterisk) require that an AM1 accessory module be installed in the AstroDAQ.

END
Must always be the last statement in a script

MESSAGE
Displays a message on the screen
example: "MESSAGE", "Test Complete"

WAIT
Pauses sequence based on the following:

TIMER - pauses for a specific number of seconds
example: "WAIT", "TIMER", "5"

TRIGGER - pauses until a trigger occurs
example: "WAIT", "TRIGGER"

NO_TRIGGER - pauses until a trigger condition is removed
example: "WAIT", "NO_TRIGGER"

CAPTURE_DONE - pauses until a capture is completed
example: "WAIT", "CAPTURE_DONE"

CLOCK - pauses until a preset time (24-hour format)
example: "WAIT", "14:30:00"

*LOGIC_IN - pauses until a logic pattern is matched
example: "WAIT", "LOGIC_IN", "10x1"

KEY - pauses until a key is pressed
example: "WAIT", "KEY"

MONITOR
Selects the state for the Monitor 1 window

OPEN
example: "MONITOR", "OPEN"

CLOSE
example: "MONITOR", "CLOSE"

LOOP
Starts loop section for between two and 1,000 loops
example: "LOOP", "5"

END_LOOP
Ends loop section

CAPTURE
Captures to record label "record_name"
example: "CAPTURE", "Test Record"

END_CAPTURE
Aborts capture in progress
example: "END_CAPTURE"

TRIGGER
Triggers AstroDAQ
example: "TRIGGER"

ARCHIVE
Archives current record to PC; user specifies existing path
example: "ARCHIVE", "C:\DATA"

SET_UNIT
Sets AstroDAQ unit number for sequence; only used in multiple unit configurations
example: "SET_UNIT", "4"

SKIP_IF
Skips the next line in the sequence based on the following:

TRIGGER
example: "SKIP_IF", "TRIGGER"

NO_TRIGGER
example: "SKIP_IF", "NO_TRIGGER"

CAPTURE_DONE
example: "SKIP_IF", "CAPTURE_DONE"

ANALOG_OUT
Specifies output voltage, select channel 1 or 2, and output voltage (-5 to +5)
example: "ANALOG_OUT", "2", "3.0"

***RELAY**
Selects relay state (open/close) for relay number 1 or 2 on the AM1 module
example: "RELAY", "OPEN", "1"

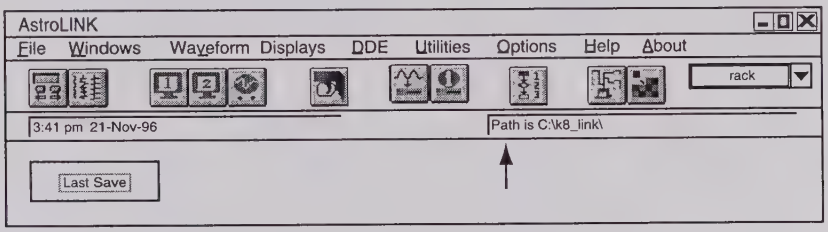
***LOGIC_OUT**
Specifies logic state (high/low) and logic output number (1 - 4)
example: "LOGIC_OUT", "HIGH", "1"

***CLOCK_OUT**
Clock frequency output (1 Hz to 50 kHz)
example: "CLOCK", "1000"

***requires AM1 accessory module**

18 ASTROLINK FILES

AstroLINK uses a variety of file types. Most of these files save parameters associated with specific functions that allow the program to be quickly restored to a previous state. When reading or writing these files, AstroLINK usually looks to the current User Path for the directory. The current User Path is always presented on the lower right side of AstroLINK's Main Menu (see below).



Unless otherwise noted, all of the files described in this section can be viewed as ASCII files, using a text processor such as Windows Notepad.

Initialization file (*.INI)

When launched, AstroLINK attempts to read the file K8LINK.INI from the Windows directory (usually c:\windows). If the file is not present, AstroLINK will create one using default values. This file is an ASCII file and can be read or modified using a standard Windows editor such as Notepad. The default version appears as follows:

```
[desktop]
UserPath = "c:\A_link\", " "

[tcpip]
TCPReadTimeOut = 5000
TCPWriteTimeOut = 5000
TCPPort = 5001
timer rate = 55

[watchdog]
limit1 = 0
limit2 = 0
```

The User Path defines where AstroLINK will look for supporting files and what it uses as a default directory.

TCP Read and Write Timeouts are given in milliseconds. These apply to the low-level network driver and should not be confused with the AstroLINK watchdog. Watchdog limits are given in seconds. Setting them to 0 disables the watchdog system.

Configuration file (*.AMC)

To simplify starting the program, AstroLINK can automatically connect to AstroDAQ enclosures on being launched. The configuration file, config.amc, contains the list of AstroDAQ enclosures to be polled for connection at startup. AstroLINK looks for the config.amc file in the directory specified by the User Path. This directory is itself specified in the initialization file. An example is shown below.

```
[resources]
mib 1 = "Unit #1", "192.1.1.81"
mib 2 = "Unit #2", "192.1.1.82"
mib 3 = "", ""
mib 4 = "", ""
mib 5 = "", ""
mib 6 = "", ""
mib 7 = "", ""
mib 8 = "", ""
mib 9 = "", ""
mib 10 = "", ""
```

A single configuration file contains the network address and a user-defined label for a maximum of ten AstroDAQs. In the example above, only the first two entries are valid, because the others have zero-length strings for label and address. There must always be ten entries.

AstroLINK tries to connect to each valid unit listed in the configuration file. If an AstroDAQ is not available or powered down, AstroLINK will time out. A message will be displayed that demands a user OK. AstroLINK then tries the next AstroDAQ on the list until all valid addresses have been tried.

The AstroLINK Configuration utility allows connection or disconnection of AstroDAQs after start up. This Configuration utility also allows the current configuration to be saved to a file. If the current configuration is saved to the file config.amc in the directory specified by the initialization User Path, the current configuration becomes the wake-up configuration. The configuration can also be saved under a different name for use at some later time. In either case, the extension for configuration files should be .amc.

If AstroDAQs are used in setups that change frequently, a config.amc with no valid addresses may be the most efficient wake-up configuration. With such a configuration file, AstroLINK will not try to connect to any AstroDAQs on startup. This eliminates messages and speeds up the wake-up process. When AstroLINK has been launched, the Configuration utility can be used to connect to an AstroDAQ.

This configuration file also contains information about custom user keys.

View file (*.AMV)

AstroLINK display functions, such as Monitor and Scope, can be configured to accommodate many applications. Configurable parameters include color, waveform size, and display mode. To avoid setting the display each time, settings can be saved as View files (*.AMV).

View files can be saved manually and are not automatically read on start up. Instead, View files are included in test sets. This allows View files to be loaded with a single mouse click.

View files are created by opening an AstroLINK display window (like Monitor or Scope) and using the Settings menu. A library of View files can be accumulated in this manner. The Make Test utility is used to make View files part of a test set.

Unit settings file (*.AMS)

An AstroDAQ has already been defined as an AstroDAQ enclosure with a set of modules. There are many adjustable parameters when setting up an AstroDAQ. Parameters include the gain of each module, sample rate, and trigger conditions. All of the parameters associated with setting up an AstroDAQ can be saved in a Unit Settings file. Unit Settings files have the ".AMS" extension.

Because Unit Settings files contain module information, the files can only be used to update AstroDAQs with the same module combinations.

Test set file (*.AMT)

A Test Set file can include View files, Unit Settings files, and an opening menu. A Test Set file is used to save and restore the entire test setup. This information includes setup parameters for each individual AstroDAQ.

In terms of module installation and options, Unit Settings files must match the AstroDAQs to which they are assigned or the settings cannot be fully restored. Also, the Test Set file must match the AstroDAQ System configuration in the number of AstroDAQs connected.

Test Set files can be assigned to any of ten available User Buttons in the AstroLINK main menu. When an assigned button is pressed, AstroLINK looks for the associated *.amt file in the directory specified by the current User Path. AstroLINK then tries to restore the system. The Make Test utilities are used to assign User Buttons to Test Set files. A label can be specified for the User Buttons. Except for button identification, User Button labels have no significance.

Filter definition file (*.AMF)

A filter definition file contains a list of filter coefficients that define the filters available through the module control menus. Each set of coefficients is associated with a text string that specifies the filter name that appears in the pull-down menu. Separate filter files for each class of waveform module are provided. The filter files must be included in the User Path or an error message will be displayed whenever the file selection pull-down menu is used.

Users who want to add or delete filters by modifying this file should contact Astro-Med Technical Support for assistance.

Other files related to AstroLINK

Additional file types used by AstroLINK are listed and briefly discussed below.

- Transducer File (*.AMU)

The only transducer file is "trans.amu". A copy of this file must be located in the User Path, or an error message will be displayed in the User Engineering Units window. The file contains unit name, scale, and offset factors for specific User Engineering units. Entries are added and deleted through the Unit Specification menu, which is reached through the module control menus.

- Sequencer File (*.AMQ)

Sequencer files are created when an AstroLINK sequence is created.

- Archive File (*.DCR)

Archive files are created when an AstroDAQ record is archived to the host PC. Archive files are primarily binary files and cannot be read by ASCII editors. Before they can be reviewed, DCR files should first be restored to an AstroDAQ.

- AstroGRAPH Settings File (*.AMR)

AstroGRAPH settings, including custom chart formats, can be saved to this type of file. Refer to the *AstroGRAPH® User Guide* for further information.

19 NETWORK CONSIDERATIONS

Except for familiarity with cabling, no network knowledge is required to use an AstroDAQ System. This section is intended to present background material for individuals with network experience. Additional information on networks is available in many introductory texts on the subject.

The AstroDAQ system uses 10Base-T cabling with RJ-45 connectors and is designed to work with Ethernet™ (IEEE 802.3) and the TCP/IP protocol.

The maximum theoretical bit rate on this type of network is 10 million bits/second. The practical rate is much lower because of network protocol overhead, operating system overhead, and competition with other network traffic. Typically, AstroLINK can upload waveform data at 30,000 samples per second.

Additional material is provided in the *AstroLINK® Installation Guide.*

AstroDAQ network addresses

The AstroDAQ data acquisition system connects to the host through a 10-MBit/sec CSMA/CD Ethernet port. End-to-end communication is accomplished using the transmission control protocol (TCP) transport of the TCP/IP protocol suite. The address resolution protocol (ARP) is used to translate physical addresses (48-bit Ethernet address) to IP addresses (32-bit internet or IP address).

AstroDAQ users have no real concern over the physical address of the AstroDAQ, because this issue is handled by ARP. The user should ensure that: 1) each AstroDAQ on the network has a different but compatible IP address, and; 2) the network being used does not have excessive non-AstroDAQ traffic.

Both the physical and the programmable network addresses are stored in nonvolatile storage (EEPROM) on the AstroDAQ backplane. The physical address is programmed at the factory to a unique number. All physical addresses are unique to all Ethernet devices.

The 32-Bit IP addresses are specified in dotted decimal notation. This notation is composed of four octets in ASCII decimal form, separated by periods. Internally, software handling IP addresses interprets up to three of the most significant bits of this address to be the network class. The network class indicates how many bits of the network address signify the network ID and how many bits signify the host ID. If the most significant bit of the IP address is a zero, the IP address is said to be a class A address.

Selecting network addresses

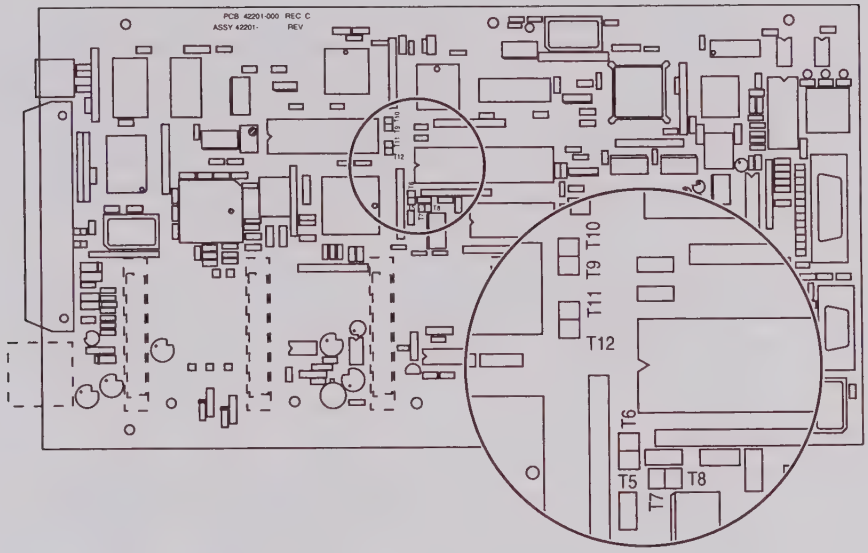
The following are requirements in selecting IP addresses for the AstroDAQ system:

- All AstroDAQs and their controlling computers must have the same IP address class and network ID.
- The IP addresses 0.0.0.0 and 255.255.255.255 are reserved and cannot be used for either the host computer or an AstroDAQ.

The AstroDAQ is equipped with four jumpers, normally used to select one of fourteen IP addresses fixed at the factory. A fifteenth combination of the jumpers selects the user-programmable IP address stored in EEPROM.

A table of the pre-set addresses and the associated jumper pattern is given below.

address	T11-T12	T9-T10	T5-T6	T7-T8
192.168.255.1	on	on	on	off
192.168.255.2	on	on	off	on
192.168.255.3	on	on	off	off
192.168.255.4	on	off	on	on
192.168.255.5	on	off	on	off
192.168.255.6	on	off	off	on
192.168.255.7	on	off	off	off
192.168.255.8	off	on	on	on
192.168.255.9	off	on	on	off
192.168.255.10	off	on	off	on
10.1.1.1	off	on	off	off
10.1.1.2	off	off	on	on
172.16.0.1	off	off	on	off
172.16.0.2	off	off	off	on
reserved	on	on	on	on
programmable	off	off	off	off



To access jumper locations:

- in AstroDAQ benchtop models, remove the jumper cover plate located on the rear of the unit.

- in AstroDAQ portable models, remove the AstroDAQ from its enclosure.

CAUTION: Take care when handling a portable AstroDAQ that has been removed from its enclosure. Never stand the removed AstroDAQ on its motherboard.

The first ten addresses are class C and require the address of the controlling PC to be of the form 192.168.255.X. The next two entries are class A and require the address of the controlling PC to be of the form 10.X.X.X. The final two addresses are class B and require the address of the controlling PC to be of the form 172.16.X.X. When installing TCP/IP software on a controlling PC's operating system, the default subnet mask should be used (i.e., 255.255.255.0 for a class C network). AstroDAQ does not support reverse ARP (RARP).

In cases where the host PC has no other network connections, a class C address is recommended. If only a single PC is used, it should have the address 192.168.255.100. Any of the first ten pre-set AstroDAQ addresses listed in the table on the previous page can be used, providing that no two AstroDAQs have the same address.

WatchDog timer

AstroLINK versions 1.1 and higher use a watchdog technique to verify that the communications link is still healthy. Every few seconds, AstroLINK will send a request for status to all connected AstroDAQs. As long as the link is healthy, the AstroDAQ should respond indicating that all is well. If the AstroDAQ does not respond, AstroLINK will display an error message signaling the user that something is wrong.

AstroDAQs with firmware version 1.1 or higher also include a watchdog. If AstroLINK does not send anything for a pre-determined period, the AstroDAQ assumes the worst and initializes the communication interface. This makes it possible for a user to re-connect without having to manually reset the AstroDAQ. This can be very important when the AstroDAQ is in another area or on the other end of a phone line.

The AstroDAQ time-out period is specified by two values in the file K8LINK.INI. The first value is the number of seconds the AstroDAQ will normally wait without communications activity before resetting its communications sockets. In cases where AstroLINK expects to be unable to communicate for a while, it can disable this first period. When that happens, the second period becomes active. The second period should be significantly longer than the first, because it is only operational in extreme situations.

In the file, these values are limit1 and limit2 under the header [watchdog]. K8LINK.INI is an ASCII file and can be edited by the user. Both limits are given in seconds. Typical values are 20 for limit1 and 1200 for limit2. They should be increased when either the host or the communications link is slower than normal, which could be for any of the following reasons:

- use of a modem to communicate with AstroDAQ
- a heavily burdened network
- a slow host computer
- activity on the part of the Windows operating system that suspends applications for long periods of time

A short time-out period can cause the AstroDAQ to reset unnecessarily. A long time-out period means that the user will have to wait longer for the AstroDAQ to reset itself if a problem occurs.

Setting the time-out values to 0 will disable the watchdog system. This is the default on a new installation and avoids the risk of false time-outs. It means that a failure in communications may go undetected for an indefinite period and the AstroDAQ must be manually reset if a problem occurs.

The values must be set to 0 when using an AstroDAQ with firmware version 1.0 or lower.

Use of phone lines and modem with AstroDAQ

Since data is sampled and saved locally, the AstroDAQ is well suited to remote control through phone lines. This means that a loss of connection will not result in a loss of data. A computer equipped with a modem can control an AstroDAQ as illustrated in the figure below.

The modem on the PC end may be internal or external, but should be capable of 28,800 bps to obtain reasonable performance. Slower modems might be acceptable in some situations. The net modem is a special type of modem that acts as a bi-directional link between the phone line and Ethernet. Astro-Med has used the Shiva NetModem/E™ 288 for this purpose.

Multiple AstroDAQs can be connected to a single phone line, if a hub is installed on the AstroDAQ side.

Windows 95 comes with everything required to dial up and connect to a remote net modem. Once this is done, AstroLINK can be run as usual. The only changes required are to the watchdog time-out settings, which are maintained in the file K8LINK.INI. If you are not using Windows 95, additional driver software may be required to use the net modem.

A document is available from Astro-Med to provide detailed instructions for connecting to a remote AstroDAQ through a net modem. Contact Astro-Med Technical Support for further information regarding this capability.

Using the PC parallel port with the AstroDAQ

AstroDAQ communicates via Ethernet and TCP/IP. Ethernet adapters for the PC are very cost-effective and can be added to almost any computer. The exception is a laptop computer that does not support PCMCIA. A parallel-port-to-Ethernet converter is available, eliminating the need for a PCMCIA slot. Contact Astro-Med Technical Support for more information.

Connecting to UNIX-based computers

AstroDAQ uses the TCP/IP protocol native to most UNIX computers. Astro-Med can provide support to users interested in connecting UNIX computers to the AstroDAQ. Contact Astro-Med Technical Support for further information regarding this capability.

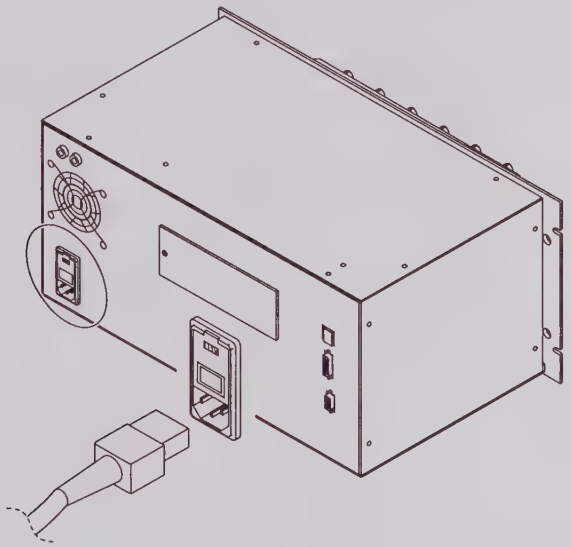
PART IV

MAINTAINING YOUR ASTRODAQ®

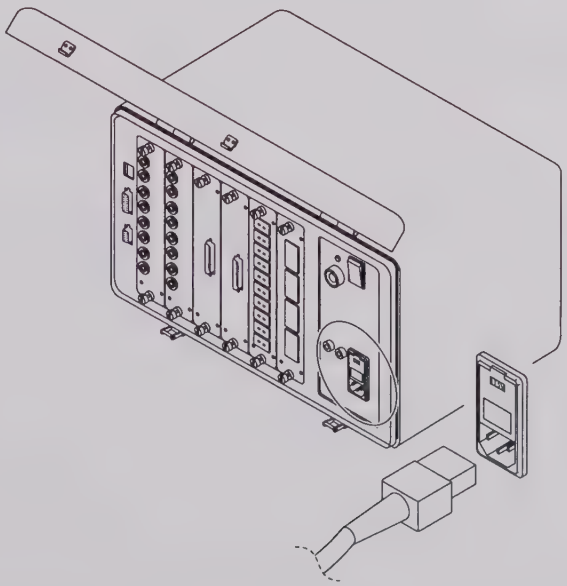
20 MAINTENANCE

Applying AC power to AstroDAQ enclosures

To apply AC power to rackmount versions of the AstroDAQ, plug the female end of the power cord into the unit's rear-panel power input.



To apply AC power to portable versions of the AstroDAQ, plug the female end of the power cord into the unit's front-panel power input.



AC power is fused at approximately 380 Watts (3.15 A @ 120 V) in the AstroDAQ. However, the AstroDAQ generally operates at much lower power levels. Typical operation is under 100 Watts, depending on the mix of installed modules.

The front-panel power switch does not disconnect AC power from the unit. When connected to a power source, the unit is always in standby. This allows the internal batteries to remain charged.

Applying DC power to AstroDAQ enclosures

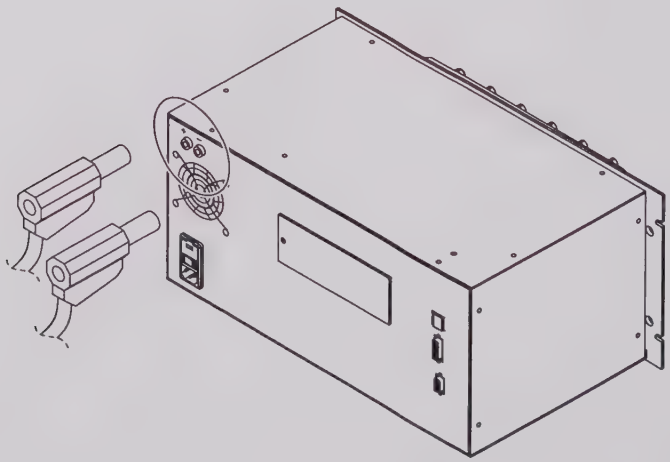
Both the rackmount and portable versions of the AstroDAQ can be powered by externally supplied DC voltage.

The AstroDAQ DC input is designed to allow operation from a typical vehicle power system based on a 12 V battery. It will function on input voltage levels between 11 V and 20 V. The AstroDAQ's battery charger will not operate fully unless the input voltage is above 14 V.

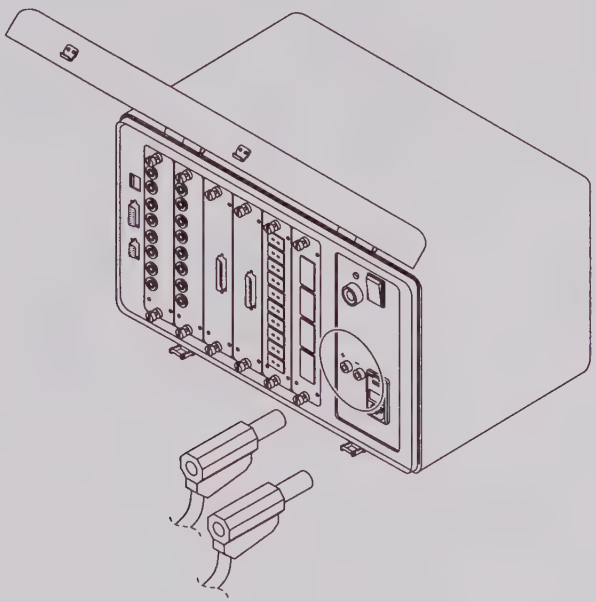
The input power is not fused within the AstroDAQ. Input power should be limited to a maximum of 12 A. This specification is a worst-case limit for safety purposes and does not indicate normal power usage. AstroDAQ power requirements depend primarily on the mix of installed modules, but 60 watts is typical.

The front-panel power switch does not disconnect DC power from the unit. The AstroDAQ is always in standby. This allows the internal battery to remain charged.

To deliver DC power from the power source to rackmount versions of the AstroDAQ, plug guarded banana jacks into the DC power connectors on the rear panel of the AstroDAQ enclosure.



To deliver DC power from the power source to portable versions of the AstroDAQ, plug guarded banana jacks into the DC power connectors on the front panel of the AstroDAQ enclosure.

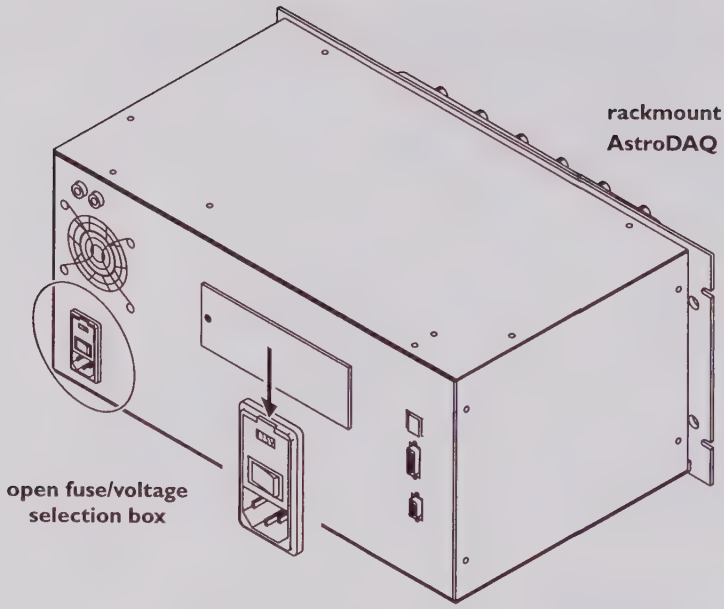


Changing the AstroDAQ's fuses or line voltage setting

WARNING: Before changing fuses or changing the line voltage setting, ensure that the AstroDAQ has been turned off and unplugged. Never change fuses or the line voltage setting while the unit is plugged in or under power.

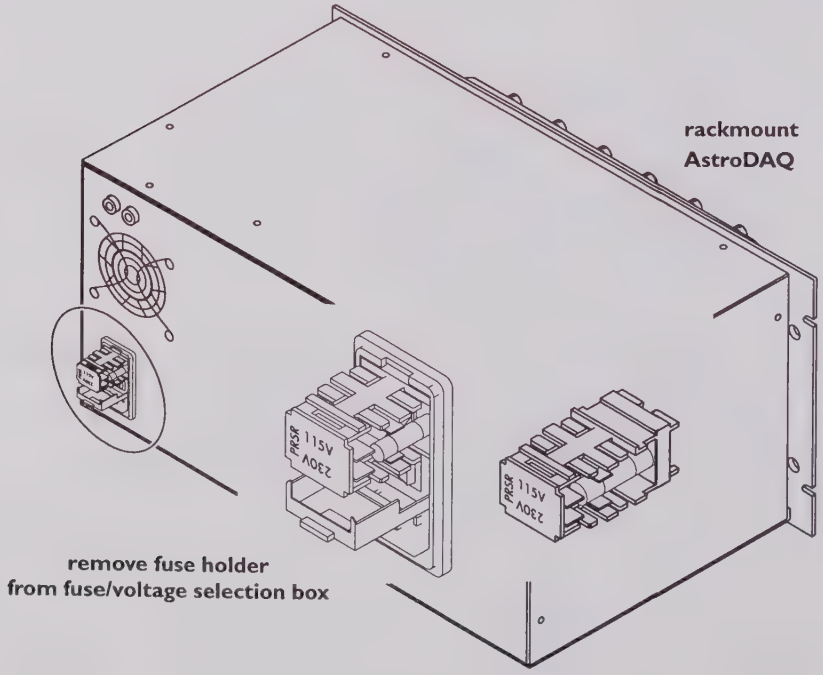
1 Locate the fuse/voltage selection box on the rear panel of the rackmount AstroDAQ enclosure and the front panel of the portable AstroDAQ enclosure.

2 Using a small flat-head screw driver, pry open the fuse/voltage selection box.



3 Locate the fuse holder in the upper part of the fuse/voltage selection box.

4 Remove the fuse holder from the fuse/voltage selection box.



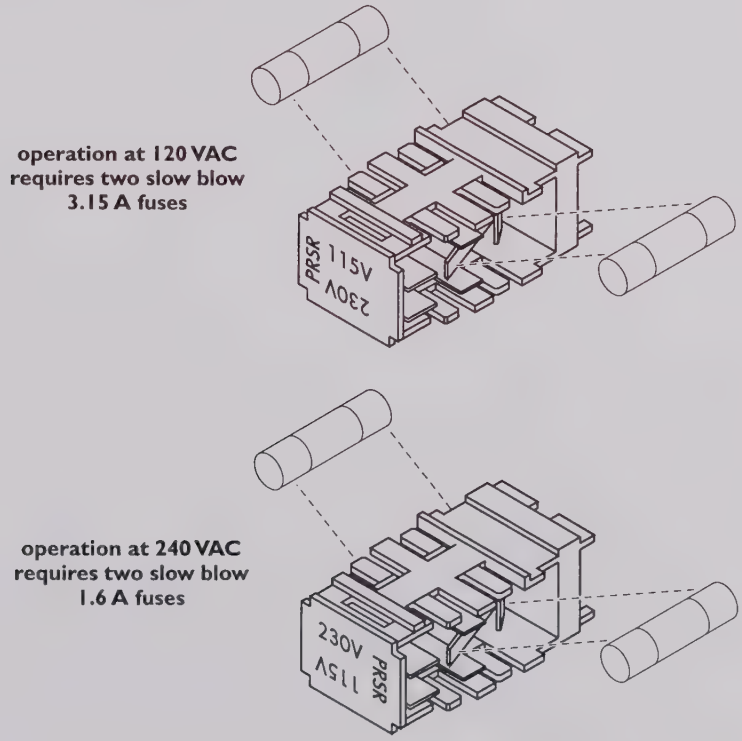
5 To replace fuses, remove each fuse from the holder and insert the appropriate replacement fuse or fuses.

- Operation at 120 VAC requires two 3.15 A fuses.
- Operation at 240 VAC requires two 1.6 A fuses.

WARNING: For continued protection against the risk of fire, replace fuses only with fuses of the same type and rating.

6 To change the line voltage setting:

- remove the fuse holder from the AstroDAQ.
- orient the fuse holder so that the line voltage you want is displayed at the top of the fuse-holder faceplate.
- ensure that the inserted fuses are of the correct type and rating for the line voltage that will be used. See the illustration below.
- re-insert the fuse holder into the fuse/voltage selection box.
- close the fuse/voltage selection box.



Changing the AstroDAQ's battery

The rackmount AstroDAQ and the portable AstroDAQ are each equipped with an internal battery pack designed to provide backup power for at least five minutes of full operation. Follow the procedure below and see the illustration on the next page to change the battery pack of either unit.

The procedure for battery pack replacement is the same for both AstroDAQ versions. However, the portable AstroDAQ must be removed from its case before performing the replacement procedure.

WARNING: Before replacing the battery pack, be sure to turn off the AstroDAQ and unplug it. Never replace the battery pack while the unit is plugged in or under power.

1 Turn off the AstroDAQ and unplug it.

2 If the battery pack of a portable AstroDAQ is being replaced:

- remove the faceplate screws that secure the AstroDAQ's electronic assembly to the case.
- remove the assembly from the case, ensuring that the removed assembly is not rested on the motherboard mounted to its rear panel.

3 Remove the screws that secure the AstroDAQ's top plate.

4 Remove the top plate and set it aside.

5 Unplug the battery harness from the power supply board.

- The battery harness consists of one orange and one black wire. Its connection is located near the middle of the power supply board's top edge.

6 Carefully position the AstroDAQ to expose its bottom.

7 Remove the three screws that secure the battery pack access plate.

8 Remove and set aside the access plate and screws.

9 Remove the old battery pack.

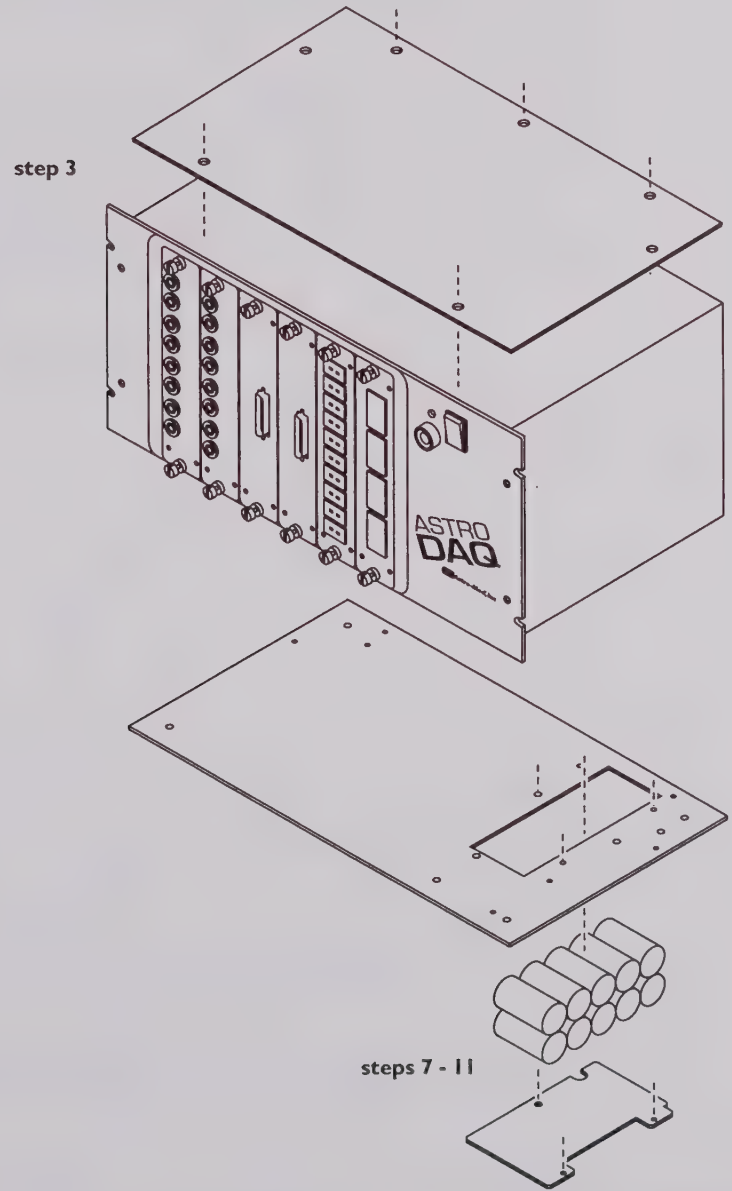
10 Insert the new battery pack, ensuring that the battery harness is accessible from the top of the unit.

11 Using the screws removed with the battery access plate in step 7, reattach the plate.

12 Plug the battery pack power harness into its connection on the power supply board.

13 Using the screws removed from the top plate in step 3, reattach the top plate.

14 If the battery pack of a portable AstroDAQ has been replaced, return the AstroDAQ electronic assembly to the portable case and reattach the assembly to the case using the screws removed in step 2.



Updating the rackmount AstroDAQ's firmware

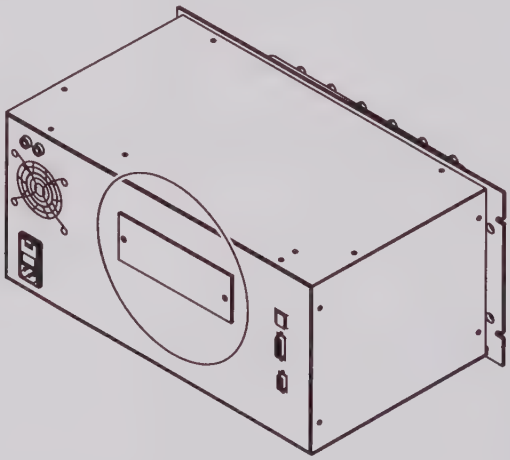
Both the rackmount version and the portable version of the AstroDAQ can be kept functionally current by replacing, as necessary, two EPROMs. In each AstroDAQ version, the pertinent EPROMs are located at positions U15 and U16 on the system's motherboard.

CAUTION: Ensure that standard anti-static procedures are used throughout the firmware replacement procedure described below. AstroDAQ electronic components can be damaged by the discharge of static electricity.

To change the firmware EPROMs in the rackmount version of the AstroDAQ:

1 Turn off the AstroDAQ and unplug it.

2 Locate the firmware access plate on the AstroDAQ's rear panel.

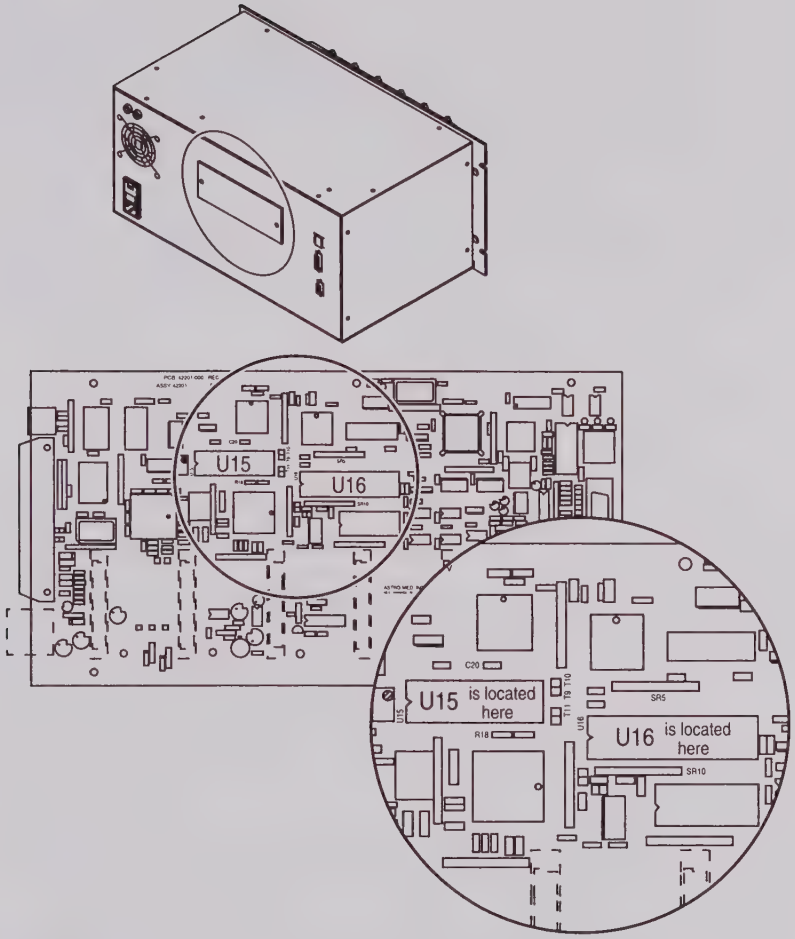


3 Remove the two screws that secure the firmware access plate.

4 In the opening created by removing the firmware access plate, locate two large firmware EPROMs at positions U15 and U16 on the AstroDAQ's motherboard.

- See the illustration on the next page. The location indicators in large letters shown in the illustration are for instructional use only and are not found in the actual AstroDAQ.

- Instead, a label is attached to each EPROM listing the number of the firmware version contained in the EPROM.



5 With a small flat-head screw driver, carefully pry each of the firmware EPROMs from its location on the motherboard.

6 Insert each replacement firmware EPROM into its appropriate socket on the motherboard.

- Ensure that the EPROMs are fully seated in their locations.

7 Using the two screws removed in step 3, reattach the rear-panel firmware access plate.

- This concludes the firmware upgrade.

Updating the portable AstroDAQ's firmware

CAUTION: Ensure that standard anti-static procedures are used throughout the firmware replacement procedure. AstroDAQ electronic components can be damaged by the discharge of static electricity.

To change the firmware EPROMs in the portable version of the AstroDAQ:

1 Turn off the AstroDAQ and unplug it.

2 Open the AstroDAQ case.

3 Remove the six screws that secure the AstroDAQ faceplate and its attached electronics to the portable case.

- Three screws are located along the top of the faceplate and three are located along the bottom.

4 Remove the faceplate and its attached electronics from the portable case.

CAUTION: Never rest the electronics assembly upright on its rear-end when it has been removed from the protection of the portable case. The portable AstroDAQ's motherboard is located on the end of the assembly. Resting the removed assembly on its end places the weight of the assembly on the motherboard and may result in damage to the exposed electronics.

5 Locate two large firmware EPROMs at positions U15 and U16 on the AstroDAQ's motherboard.

- A label is attached to each EPROM listing the number of the firmware version contained in the EPROM.

6 With a small flat-head screw driver, carefully pry each of the firmware EPROMs from its location on the motherboard.

7 Insert each replacement firmware EPROM into its appropriate socket on the motherboard.

- Ensure that the EPROMs are fully seated in their locations.

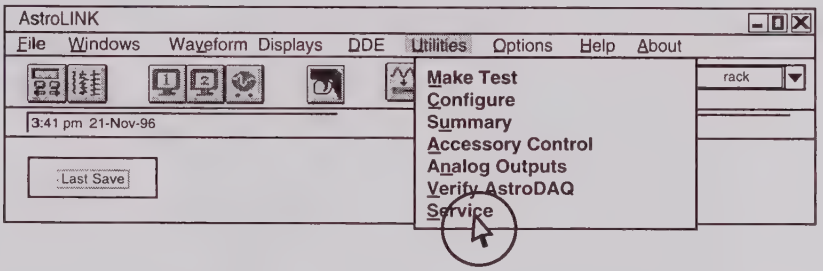
8 Return the AstroDAQ electronics assembly to the portable case.

9 Using the six screws removed in step 3, reattach the assembly to the portable case.

- This concludes the firmware upgrade.

Using AstroLINK service menus

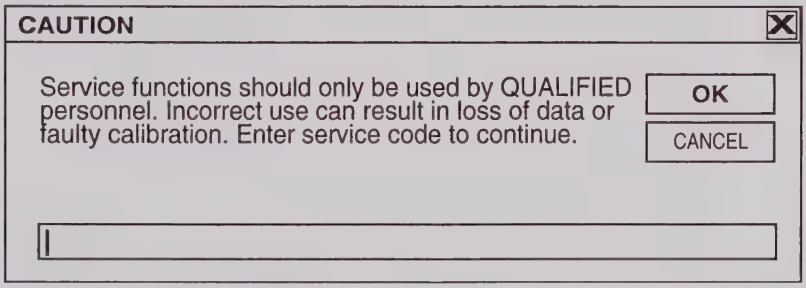
A variety of diagnostic and maintenance functions are available in the Service selection under the Utilities pull-down menu.



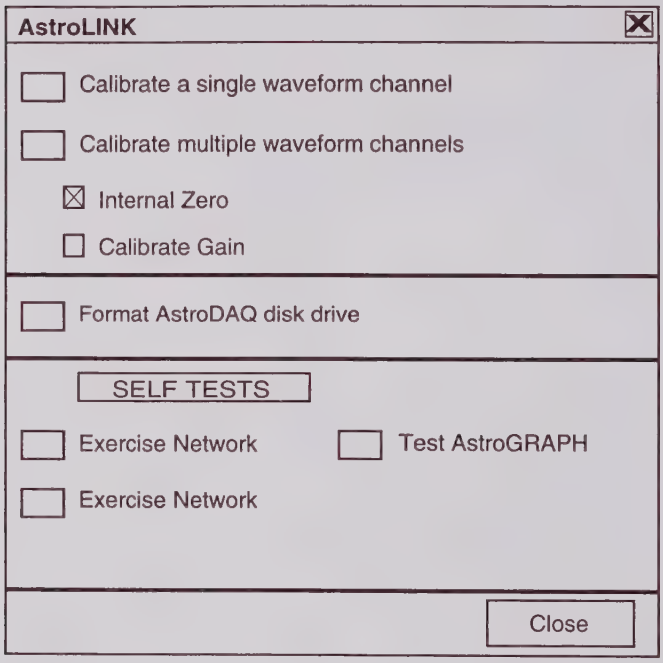
The functions available from the Service menu are powerful and include AstroDAQ calibration options, hard-disk formatting, self-tests, and network evaluation. Because the functions are powerful, the Service menu should be used only by the technically knowledgeable. To ensure that the Service menus are not entered accidentally, a CAUTION screen is displayed when Service is selected. The CAUTION screen prevents the Service menu from being accessed unless a service code is entered.

NOTE

The AstroDAQ service code is 911.


CAUTION
Service functions should only be used by QUALIFIED personnel. Incorrect use can result in loss of data or faulty calibration. Enter service code to continue.
OK
CANCEL

When the AstroDAQ service code of 911 has been entered, the service selection menu shown below is displayed.



AstroDAQ calibration options

Select to format AstroDAQ's internal hard disk. NOTE: All data currently on the hard disk will be destroyed; all data will be lost and unrecoverable.

AstroDAQ self-test options. NOTE: An AstroDAQ must have at least one record on the hard drive in order to properly perform the self-test.

UTILITY port signals

A list of signals available at the AstroDAQ UTILITY port is given below.

pin	description
1	5 V (current-limited)
2	external abort in
3	external sample clock
4	reserved
5	reserved
6	analog output #1
7	analog output #3
8	analog common
9	trigger
10	abort out
11	reserved
12	reserved
13	digital common
14	analog output #2
15	analog output #4

NOTE

Pin numbers listed as "reserved" should not be used. Reserved pins may carry active signals. Misuse of reserved pins could result in damage to the AstroDAQ. In no case should voltages above 15 V or below -15 V be found on this connector.

Signal notes

digital common/analog common
Digital Common should be used as the signal reference for all signals except analog outputs. Analog outputs should use Analog Common as the signal reference. Internally, these commons are connected together, but separating analog and digital commons can reduce interference.

trigger
Trigger is an open collector line that functions as both an input and an output. This line should be driven low (0 V) for at least 90 microseconds in order to generate an AstroDAQ trigger. Up to ten AstroDAQs can be connected on a single trigger line, so that a trigger generated by any one will create a trigger on all.

The Trigger line is normally high. As long as trigger conditions are met, the line will pulse low every 200 microseconds. It will only remain low for approximately 100 microseconds, unless held low by an external source.

abort In/abort Out
Abort In can be used to end an active Data Capture. Abort Out is a buffered version of Abort In. Abort Out is not asserted if the capture ends normally or is aborted through AstroLINK. Both Abort In and Abort Out are active low (0 V).

If Abort In is asserted by an external source, it should be kept low for at least 20 milli-seconds to guarantee that the capture will be aborted. A maximum of ten AstroDAQs can be connected such that Abort Out from one AstroDAQ is connected to the Abort In of another. This creates a hierarchical Abort structure so that aborting the AstroDAQ at the top of the chain causes all data captures in lower AstroDAQs to be aborted.

external sample clock
External Sample Clock can be used by an external source to control AstroDAQ data capture sample rates. A maximum of ten AstroDAQs can be synchronized by connecting all Sample Clocks to an external source. The External Sample Clock is only active if the data capture is specified for external sample rate. The External Sample Clock should have a minimum pulse width of 300 microseconds and a maximum frequency of 1000 Hz. Samples are obtained on the rising edge of this clock. External sample rate inputs must be TTL compatible.

INDEX

INDEX

Index

A

AC3 high voltage input module 12-1
  channel specifications 12-3
  input connectors 12-2
  input stage, diagram of 12-2
  parameter-adjustment window 12-4
AM1 accessory module
  accessory control menu 11-2
  alarm mode
    alarm source, activating 11-7
  drop-out, detecting 11-14
  events, maximum 11-1
  features 11-1
  fusing, onboard 11-12
  general description 11-1
  input/output capabilities, evaluating 11-2
  limitations, usage 11-1
  monitor alarm mode 11-7
  pinouts description 11-8
  relays
    activate signal 11-10
    breakdown voltage ratings 11-10
  slew rates for sinusoids 11-13
  slew trigger
    configuring 11-6
    processing 11-12
  technical notes 11-12
  trigger window
    final OR stage 11-4
    variable channel AND/OR stage 11-4
    variable channel trigger elements 11-5
  trigger features 11-3
  voltage level outputs 11-11
AM2 accessory module 11-1
Analog outputs 4-5
Analog-to-digital conversion 1-2
Anti-alias filtering 4-2
AstroGRAPH
  description of 1-3
  playing back data 14-8
  settings file 18-4
AstroLINK software. *See also* file types.
  adding units 3-2, 3-4
    default configuration file 3-5
  configuration utility 18-2
  initializing 3-2
  IP address 3-4
  main menu 18-1
  main window 3-3
  network connections utility 3-4
  sequencer commands 17-5
  toolbar 3-3
  unit label 3-4

B

Bandwidth 4-2
Binary event input module. *See* EV16.
BR4 bridge module
  auto-balance (nulling) functions 7-11
  basic DC bridge 7-8
  bridge arrangements, other 7-19
  calibration, basic 7-9
  calibration, secondary 7-9
  differences between BR4H and BR4A 7-1
  filtering and DSP functions 7-5
  gain correction 7-9
  general description 7-1
  input connectors and pin diagram
    BR4, BR4A, BR4H 7-4
  input stage diagram 7-2
  load cells 7-13
  menu limits
    using mV/V measurement type, BR4/A/H 7-5
    using the micro-strain measurement type 7-5
  operating parameters 7-6
  quarter-bridge circuit
    completion resistors 7-18
    configuration, physical setup of 7-18
    general description 7-17
  resistors, calibration 7-12
  specifications, BR4, BR4A, BR4H 7-3
  strain gauges
    gauge construction 7-16
    gauge factor (Gf) 7-16
    strain 7-15
    stress 7-15
  switches, board-mounted 7-2
  transducer, linear variable differential 7-14
  transducer wiring requirements 7-19
  transducers, potentiometric 7-12
  transducers, pressure 7-14

Index

C

Channels
  adding and deleting 16-2
CO8 counter module
  configuring 10-6
  counter mode
    amplitude scale 10-3
  general description 10-1
  input connectors and pin diagram 10-5
  input specifications 10-1
  input stage diagram 10-2
  rate meter mode
    amplitude scale 10-4
    count period 10-4
  switch closures, monitoring 10-6
Converting
  module unit to user engineering unit 4-3
Core trigger 13-6
Counter module. *See* CO8.

D

Data acquisition. *See* data capture.
Data capture. *See also* record management
  adding notes (notes feature) 13-9
  AM1 triggering 13-7
  arming the system 13-2, 13-6
  capacity 2-1
  data capture control window
    auto trigger 13-2
    parameter choices, summarizing results of 13-5
    parameters, defining data capture 13-3
    pre-trigger data, specifying percentage of 13-4
    sample periods, number of 13-3
    sample rate 13-3
    time required for data capture 13-4
  multiple AstroDAQs, with 13-8
  sample rate, dual 13-7
  sample rate, external 13-8
  scope tool
    arm button 3-10
    capture mode 3-10
    continuous 3-10
    one-shot 3-10
    triggered 3-10
  specifications 2-1
  triggering 13-2
  triggering data captures 13-6
DDE capability 3-6
Differential voltage input module. *See* VO8, VO8H.
Digital signal processor
  in signal conditioner modules 1-2
  theory of 4-1, 4-2

E

Engineering units 4-3
  offset 4-4
  scale 4-4
Ethernet. *See* network.
EV16 binary event input module
  calibration 9-1
  configuring 9-4
  general description 9-1
  input connector 9-3
  input diagram 9-2
  pin descriptions 9-3
  switches, board-mounted 9-2
  switch closures, monitoring 9-4
EV16A high voltage event module
  general description 9-6
  input connector assignments 9-8
  input connectors 9-7
  input diagram 9-6
  input specifications 9-7
Event processing 4-4

F

File types
  additional types 18-4
  configuration file (*.amc) 18-2
  default configuration file 3-5
  filter definition file (*.amf) 18-4
  initialization file (*.ini) 18-1
  test set file (*.amt) 18-3
  unit settings file (*.ams) 18-3
  view file (*.amv) 18-3

Filtering. *See also* individual module specifications.
anti-alias 4-2
signal conditioner modules 4-2
Fuse. *See* maintenance, fuse.

G

Grounding
enclosure grounding 4-7
uses of 4-6

H

Hard disk. *See also* data capture.
capacity 1-3
HELP function
on-line help 3-5, 3-6
Host interface
desktop pc 3-1
host pc 3-1
TCP/IP protocol 3-1

I

Input impedance. *See also* individual module specifications.
definition of 4-6
IP address 3-5. *See also* network.
Isolated voltage input module. *See* VO4.

M

Maintenance
AC power
requirements 20-2
battery, changing the 20-6
firmware
updating portable AstroDAQ 20-10
updating rackmount AstroDAQ 20-8
fuse amp requirements 20-5
fuse, changing 20-3
line voltage setting, changing 20-3
service menus
service code 20-11
service selection menu 20-12
using 20-11
signal notes 20-14
Make test
make test set window
using 16-4
make test window
AstroDAQ functions 16-1
channels, adding and deleting 16-2
comparison, test sets and sequences 16-3
enable/disable channels 16-1
trigger settings, effects on 16-2
settings, restoring previous 16-7
test design process 3-7
test sets
custom keys, assigning 16-6
waveform broadcasting 4-2
Measurements
amplitude 14-3
time 14-3
Modem 19-5
Module control window 3-7

N

Net modem. *See* modem.
Network
bit rate 19-1
connecting to UNIX-based computers 19-6
ethernet 19-1
general information 19-1
IP addresses 19-1
network addresses
jumper locations, accessing 19-3
selecting 19-2
TCP/IP protocol 19-1
timer, watchdog
time-out period 19-4
Network connection
direct connection 3-1
network connection utility 3-4
portable AstroDAQ 3-1
rackmount AstroDAQ 3-1
Notes feature. *See* data capture.

Index

P

Parallel port, using with the AstroDAQ 19-5
Path, user 3-3, 18-1
Power
  AC
    applying to AstroDAQ enclosure 20-1
    requirements 20-2
  DC
    applying to AstroDAQ enclosure 20-2
    requirements 20-2

R

Real-time recording. *See* AstroGRAPH.
Real-time waveforms
  comparison: monitor, scope, review 15-5
  monitor settings window
    meter format, selecting 15-10
    time-base resolution 15-4
  monitor window 15-1
    alarm mode 15-2
    amv view files 15-2
    format, selecting a waveform monitor 15-3
    mode options 15-2
    saving waveforms on host disk 15-6
    scroll format 15-3
    setting up 15-2
    trigger source options 15-6
    waterfall format 15-3
    wiper format 15-3
  monitoring 15-1
  monitors, using both 15-3
  waveform setup window
    using 15-8
  X-Y plot format, selecting 15-9
Record management tool
  archive to host feature 14-9
  chart button 14-8
  disk space, freeing 14-9
  display, changing 14-4
  markers feature 14-5
  quantifying waveform data 14-3
  record, delete 14-8
  record maintenance 14-8
  record playback 14-8
  record review
    reference capture 14-6
    screen setup options 14-2
  record, search for 14-8
  signal values, minimum and maximum 14-3
  waveform setup window
    display, changing waveform 14-4
  zoom button 14-3
Relay driver circuit
  low and high states 4-4

S

Sample rate. *See* data capture, scope tool.
Saving waveforms on host disk 15-6
Scope tool
  displaying waveforms 3-11, 3-12
  features of 3-12
  introduction to 3-8
  waveform setup window 3-11, 3-12
  window 3-9
  zoom button 3-11
Sequencer tool
  general description 17-1
  sample sequence 17-3
  script file 17-3
  sequencer commands 17-5
  sequencer files 17-1
  sequencer script 17-4
  sequencer window
    running a sequence 17-2
Service. *See* maintenance.
Signal conditioner modules. *See also* individual module specifications.
  channel capacity 2-1
  component relationships 4-1
  general description 1-2, 4-1

Specifications. *See also* individual module specifications.
AM1 accessory module 2-5
AstroLINK software 2-2
data capture 2-1
definitions 4-6
environmental 2-3
host interface 2-2
modules
general 2-1, 2-4
power 2-2
regulatory compliance 2-5
shock/vibration 2-3
trigger 2-2
System
configuration 1-4, 1-5
functions 1-6
overview 1-1

T

TC10 thermocouple input module
filtering and DSP functions 8-2
general description 8-1
input stage diagram 8-1
linearizing TC measurements 8-4
menu limits 8-2
reference junctions 8-4
specifications 8-2
thermocouple measurements 8-3
thermocouple types 8-1
Thermocouple input module. *See* TC10.
Trigger control. *See* AM1 and core trigger.
Troubleshooting. *See also* maintenance.
connecting to AstroLINK 3-4
TTL compatibility 4-4

U

User engineering units. *See* engineering units.
Utility port signals
notes 20-13
pin descriptions 20-13

V

VO4 isolated voltage input module
amplifier, isolation 6-5
calibration 6-5
filtering and DSP functions 6-3
input connectors 6-2
input stage diagram 6-2
iso-common signal reference 6-5
menu limits 6-3
normal mode rejection 6-6
operating parameters 6-4
shorting inputs using AstroLINK 6-1
specifications 6-2
VO8, VO8H differential voltage input module
calibration, VO8 5-5
differential voltage measurements
common mode rejection 5-6
common mode voltage 5-6
gain correction 5-5
general description 5-1
input stage diagram 5-2
menu limits 5-3
operating parameters, VO8 5-4
options, VO8 5-7
resistance temperature detector (RTD) 5-7
strain-gauge applications 5-1

W

WatchDog timer 19-4
Waveforms
broadcast rate 4-2
broadcasting 4-2
quantify waveform data 3-11
signal values 3-11
Windows 95 1-1, 3-1, 19-5
Windows for workgroups 1-1, 3-1
WinSave. *See* saving waveforms on host disk.